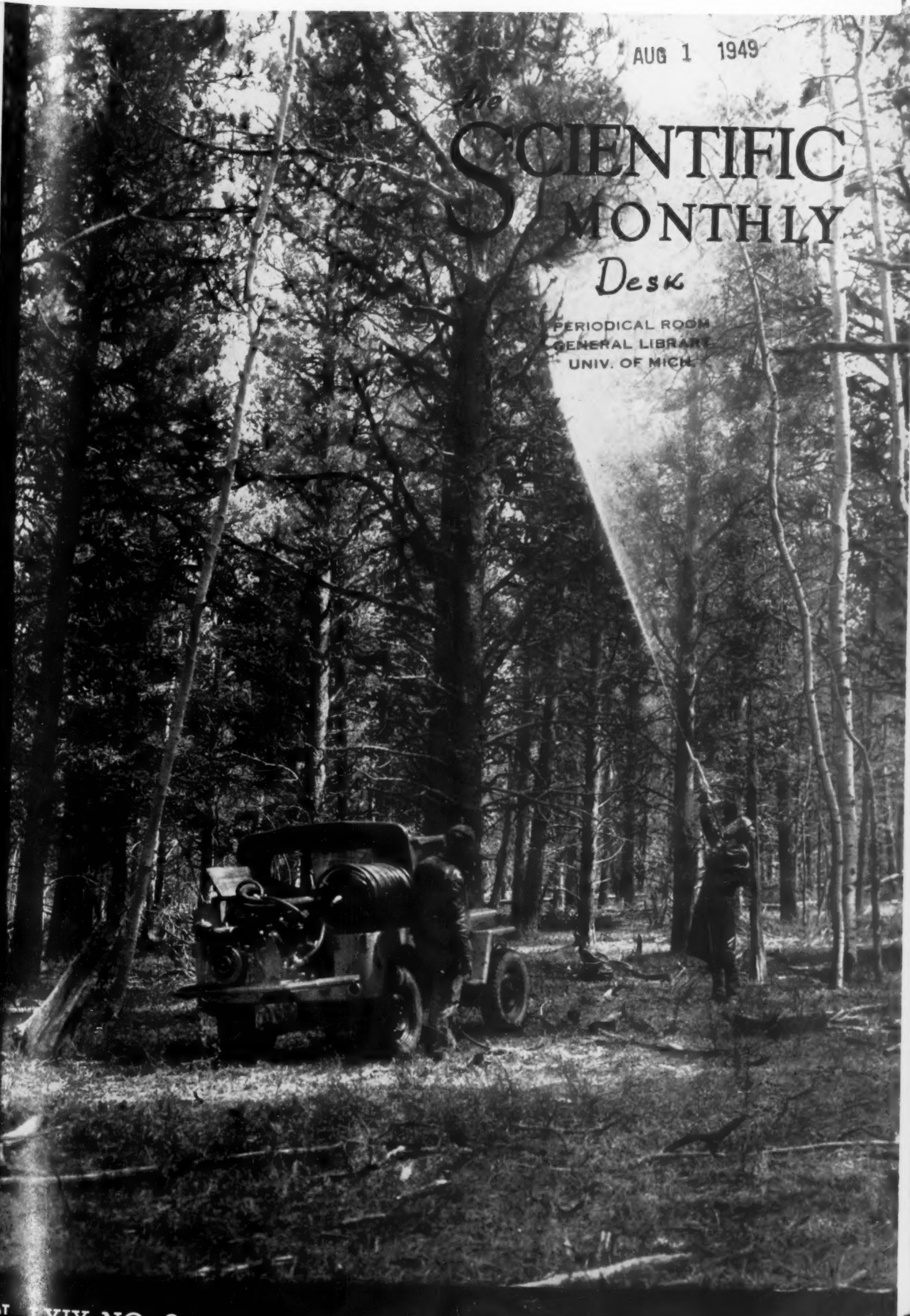
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EVOLUTIONARY GROWTH RATES IN THE DINOSAURS*

EDWIN H. COLBERT

Dr. Colbert (Ph.D., Columbia, 1935), who is curator of fossil reptiles, amphibians, and fishes at The American Museum of Natural History, of New York City, where he has been an associate since 1930, is spending the summer doing reconnaissance in the Triassic sediments of Southwestern United States.

MOST people may not know much about dinosaurs, but in this day of widely disseminated popular publications, of moving pictures, and of radio, the public is fully aware of the fact that such animals once lived on the earth. Moreover, because of publicity given to the large dinosaurs of upper Mesozoic times, there exists a nearly universal concept that all the dinosaurs were huge beasts; that they were veritable giants in the ancient world. Indeed, the word *dinosaur* has become almost synonymous in many minds with the word *giant*.

It is true that many—in fact a majority—of the dinosaurs were what we might call giants, animals 15 feet or more in length, with probable weights of several to many tons. Not all of them were large, however; some dinosaurs were of very moderate size, and some of them were quite small. Yet, even though there were small and medium-sized dinosaurs, these reptiles were on the whole giant animals, because out of about 230 genera of dinosaurs known at the present time, at least 150 genera were giants. Giantism was a dominant trend in dinosaurian evolution.

Evidently large size was generally advantageous to the dinosaurs during the long course of their history, which began in the Triassic period of the Mesozoic era and extended through the Jurassic and Cretaceous periods. Many lines of dinosaurs evolved during the 100 million years or more of Mesozoic history in which they lived, and in most of these lines of ascent there was an early trend toward giantism. In those days the earth had a tropical or subtropical climate over much of its land surface, and in the widespread tropical lands there was an abundance of lush vegetation. The land was low, and there were no high mountains forming physical or climatic barriers. Conditions were therefore favorable for the evolution of large plant-eating, or herbivorous, reptiles, and of course the development of large herbivores led to the simultaneous evolution of large meat-eating, or carnivorous, reptiles.

Such trends toward large size frequently appear in certain groups of animals. We are familiar with this evolutionary phenomenon today as it is seen in the elephants. The elephants are giants, and through most of their evolutionary history they were giants. To a lesser degree the same can be said for such animals as the rhinoceros or the hippopotamus.

It is interesting to note that giantism was achieved independently by various separate lines of dinosaurian evolution. Time and again in the collective history of these reptiles a phylogenetic line had its beginnings with small animals and very quickly progressed to animals of large or even huge size. This pattern of size growth was repeated over and over at different times during middle and

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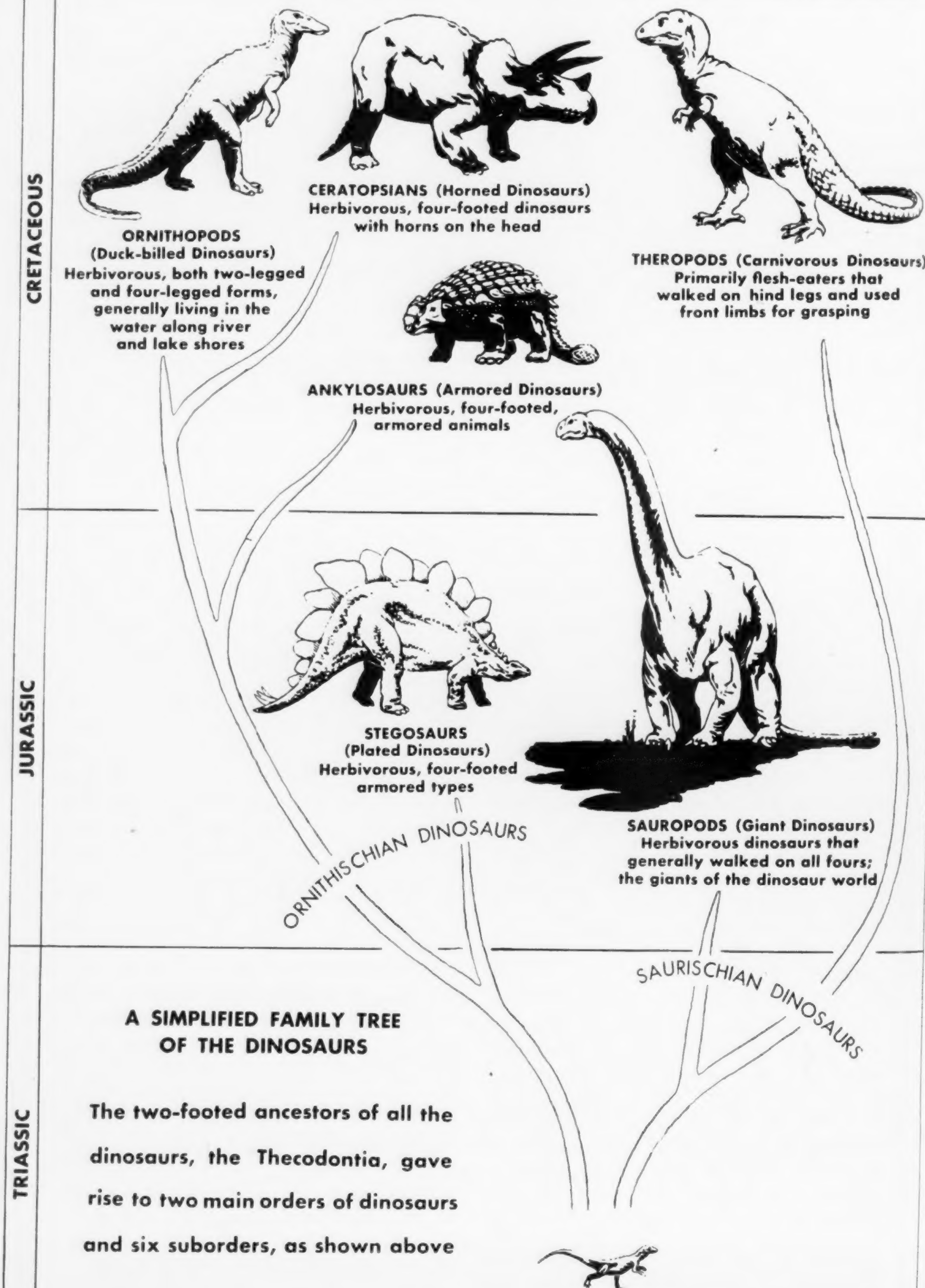

CRETACEOUS
JURASSIC
TRIASSIC
ORNITHOPODS
(Duck-billed Dinosaurs)
Herbivorous, both two-legged and four-legged forms, generally living in the water along river and lake shores
CERATOPSIANS (Horned Dinosaurs)
Herbivorous, four-footed dinosaurs with horns on the head
THEROPODS (Carnivorous Dinosaurs)
Primarily flesh-eaters that walked on hind legs and used front limbs for grasping
ANKYLOSAURS (Armored Dinosaurs)
Herbivorous, four-footed, armored animals
STEGOSAURS
(Plated Dinosaurs)
Herbivorous, four-footed armored types
SAUROPODS (Giant Dinosaurs)
Herbivorous dinosaurs that generally walked on all fours; the giants of the dinosaur world
ORNITHISCHIAN DINOSAURS
SAURISCHIAN DINOSAURS
A SIMPLIFIED FAMILY TREE OF THE DINOSAURS
The two-footed ancestors of all the dinosaurs, the Thecodontia, gave rise to two main orders of dinosaurs and six suborders, as shown above
THECODONTIA
Ancestors of all dinosaurs

upper Mesozoic earth history; various small dinosaurs evolved into giants during the Jurassic period, and again during the Cretaceous period. Wherever and whenever the different dinosaurs evolved, they were more likely than not to grow into giants.

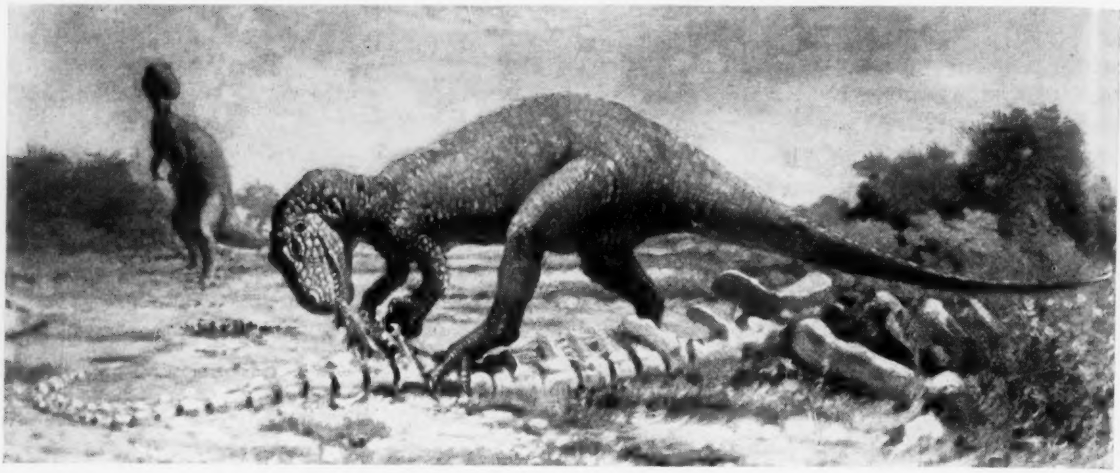
The independent evolution of giants among the different lines of dinosaurs at different times during the Mesozoic era leads to the question with which we are particularly concerned at this place—namely, how fast was giantism attained in the several groups of dinosaurs? Was the progression from small ancestors to giant culminating descendants roughly the same in all the lines, or were there differing rates of evolutionary growth? In any particular evolutionary line was the phylogenetic growth from ancestor to end form a constant progression in size through the ages, or were there differing rates within the single developing line? What does the fossil record show us?

The fossil record shows us quite a lot, but not as much as we would like to know. Fossils have a way of occurring sporadically, both geologically and geographically, rather than being evenly distributed through the sequence of sediments as they are exposed in all parts of the world. At some stratigraphic levels and in some localities fossils can be very abundant indeed; at other levels and localities the rocks can be completely barren of fossils. Consequently, when we undertake to study any particular group of animals in the fossil record we find that our data consist of various suites of materials with geologic and geographic gaps between them. These limitations must be accepted and allowed for in any attempt to study fossil animals, particularly when the study involves such a subject as evolutionary rates, where, perforce, a complete record is desirable. It is necessary to go ahead in the best way possible with the materials available.

When we look at the fossil record we see that the dinosaurs evolved as two distinct orders of reptiles, known as the Saurischia and the Ornithischia. It is quite evident that these two orders arose from a common ancestry, because they have many morphological characters held in common that show their relationships to each other. In spite of certain resemblances and common characters, however, the two orders were separate from the very beginnings of their phylogenetic histories.

The first dinosaurs, appearing in beds of upper Triassic age, were, for the most part, small, primitive saurischians belonging to a suborder known

The small theropod dinosaur, *Ornitholestes*, of upper Jurassic age, shown catching the earliest known bird, *Archaeopteryx*.



Allosaurus was a giant meat-eating theropod of upper Jurassic age, commonly 30 feet or more in length. Shown here feeding upon the carcass of *Brontosaurus*.

as the Theropoda. They were lightly constructed little dinosaurs with hollow, fragile bones, and they were completely bipedal. They walked around on strong hind limbs, and the fore limbs, which were small, were used to aid in feeding. They were meat-eaters, and their jaws were armed with sharp teeth. One might say that these primitive theropods set a basic pattern from which many later and more highly specialized lines evolved.

One such line is exemplified by the progression from the genus *Coelophysis* of the upper Triassic period to *Ornitholestes* of the upper Jurassic period. *Coelophysis* was a primitive theropod, built along the lines described above as characteristic of the early dinosaurs. It must have been a very agile little dinosaur than ran through the jungle undergrowth in search of small reptiles and insects.

Ornitholestes, living many millions of years later than *Coelophysis,* was remarkably like its Triassic predecessor in size and structure, because it too was a small, quickly moving carnivore that pursued and caught lesser animals on which it fed. The Jurassic dinosaur maintained, 40 million years later, the same adaptations for the same mode of life that had been established by the Triassic dinosaur. From *Coelophysis* to *Ornitholestes* there was very little evolution, either as to structure or size. This was a slow line of evolutionary development.

From this slow evolutionary line there evolved a branch, however, that showed a considerable amount of evolution in both structure and size. This line culminated in the genus *Struthiomimus* of upper Cretaceous age. *Struthiomimus* lived about 40 million years later than did *Ornitholestes* and about 80 million years later than did *Coelophysis,* and during the lapse of time after this particular branch of dinosaurian evolution appeared as an offshoot from the primitive theropod heritage there was a considerable trend to increase in size. Whereas *Coelophysis* and *Ornitholestes* were animals that measured 6 or 7 feet in length, with probable weights in life of about 40 or 50 pounds, *Struthiomimus* had a length of 16 feet and a probable weight in life of several hundred pounds. Thus the later dinosaur increased in size many times over its earlier and more primitive relatives.

Though this size increase of *Struthiomimus* over its ancestors was striking indeed, the fact is that *Struthiomimus* at the most attained only a moderate degree of giantism. It was a big reptile as compared with most reptiles with which we are acquainted at the present time, but it was rather small as compared with many dinosaurs with which it was contemporaneous; in fact, it was small as compared with many other theropods.

At an early stage in theropod history, there was a definite trend toward giantism, with the result that many genera of these dinosaurs became very large. These were the theropods collectively known as the carnosaurs, which probably arose in upper Triassic times as an offshoot from the small primitive theropods that already have been described. The trend toward giantism was apparent even in the ancestral Triassic carnosaurs, exemplified by such genera as *Zanclodon* or *Palaeosaurus.* It continued through the Jurassic period where, in late Jurassic times, we find the meat-eater *Allosaurus,* a dinosaur 30 feet or more in length with a weight in life of several tons. It continued through the Cretaceous period in such forms as *Gorgosaurus,* comparable to *Allosaurus* in size, and culminated in the truly great giant, *Tyrannosaurus,* of upper

Cretaceous age, an animal that measured almost 50 feet in length. It is interesting to see that throughout the evolution of these giant meat-eaters, the pattern of structure established by the small, primitive carnivores of the Triassic period was followed. In spite of their great size, the giant carnosaurs retained the bipedal pose of their ultimate ancestors; for active, predaceous dinosaurs this was a very efficient method of locomotion.

In this review of evolution in the theropod dinosaurs there is an answer to the questions that were raised at the beginning of the discussion. The theropods do show that there were differing evolutionary growth rates during the Mesozoic era. The line from *Coelophysis* to *Ornitholestes* was a slow-rate line (so far as increase in size is concerned), and that culminating in *Struthiomimus* was a moderate-rate line. As contrasted with these lines, the line of carnosaurian evolution, beginning in the Triassic and culminating in *Allosaurus* of the upper Jurassic, was a fast-rate line. In the slow-rate line there was little if any size increase during a lapse of some 40 million years, whereas in the fast-rate line the size was increased a great many times over in the same amount of time.

Moreover, the theropods illustrate the fact that evolutionary rates vary within a single developing phylogenetic line. In the evolution of the carnosaurs the greatest relative increase occurred during lower and middle Jurassic times, so that by the time *Allosaurus* made its appearance in the upper Jurassic period most of the growth to giantism had taken place. During the 60 million years of time after *Allosaurus* the increase of size among the carnosaurs was relatively minor. Many of the later meat-eaters were no larger than *Allosaurus,* and in only a few, such as the giant *Tyrannosaurus,* was there an increase of significant proportions. Consequently, the evolutionary growth rate in these dinosaurs can be pictured as an asymmetrical curve on a graph, which quickly approaches the limits of its greatest height and then levels off in a comparatively gentle slope.

The other lines of dinosaurian evolution give additional information as to differential rates of size increase, not only with regard to rates between separate phylogenetic lines but also as regards the rates within single lines. It may be of interest to consider some of them here.

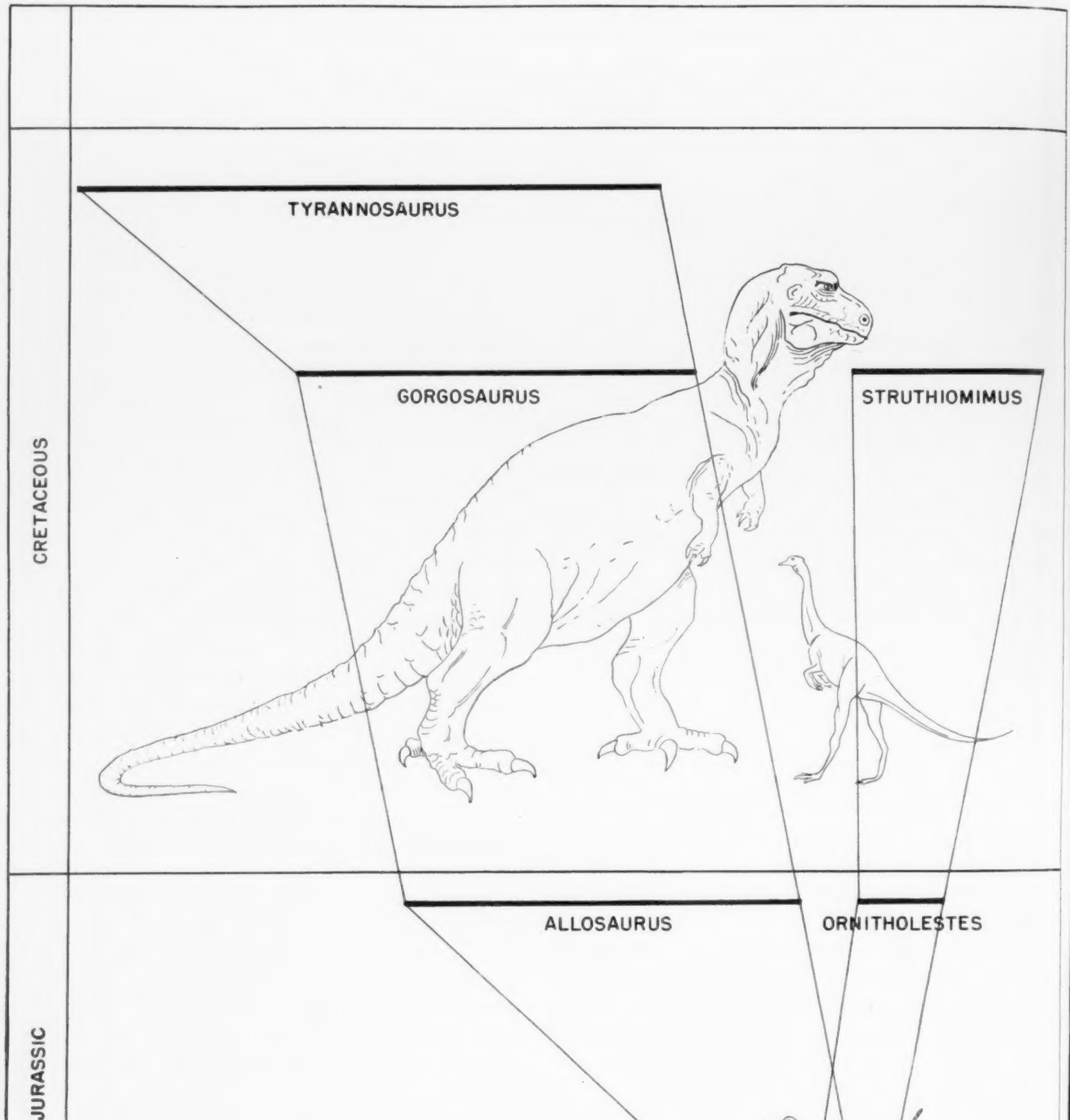
There was another suborder of the Saurischia known as the Sauropoda. These were giants among giants, the greatest of all the dinosaurs. They were great herbivores, with tremendously long necks and tails, massive bodies, small heads, and heavy, postlike legs. No longer were they bipedal, like their ancestors but, rather, because of their great size, were completely quadrupedal in posture. They lived for the most part in swamps, where they fed upon the abundant vegetation that grew in these places.

The ancestral sauropods, exemplified by the genus *Plateosaurus,* were dinosaurs of moderately large size that lived in upper Triassic times. Even at this early stage of their history they developed the trend toward giantism that was to be so characteristic of the sauropods, and they were many times larger than most of the contemporary meat-eaters. Evolution toward great size continued at a comparatively rapid rate in this line of dinosaurs, so that by the end of the Jurassic period the sauropods had attained, in such animals as *Brontosaurus* or *Brachiosaurus,* the ultimate in size, not only among all the dinosaurs, but also among all land-living animals. There was no increase in size among the sauropods after the Jurassic period, which can be attributed to the probable fact that the Jurassic sauropods had become about as large as land-living animals can be.

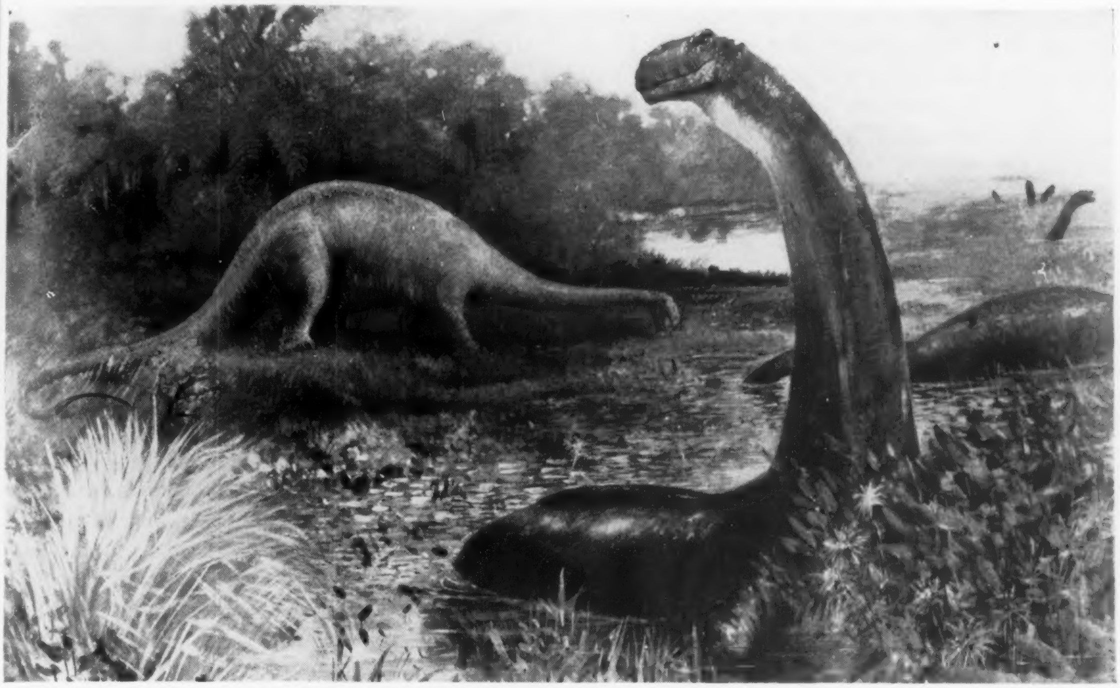
The ornithischian dinosaurs were, on the whole, a later and more highly evolved order of reptiles than were the saurischians. Their early representatives appeared later than did the early saurischians, and their various evolutionary branches developed at later stages in Mesozoic time than did the branches of saurischian evolution. Because of the late appearance of many of the ornithischians, their evolutionary histories were relatively short as compared with the histories of the saurischians. The contrast is interesting and instructive.

There were four suborders of the ornithischians: the Ornithopoda, or duck-billed dinosaurs; the Stegosauria, or plated dinosaurs; the Ankylosauria, or armored dinosaurs; and the Ceratopsia, or

Tyrannosaurus, the largest of the meat-eating dinosaurs. This was among the last of the dinosaurs to live during the final phases of Cretaceous times.



Size increase in two lines of theropod dinosaurs. One line, culminating in *Struthiomimus,* shows a moderate increase in size from the small ancestral types; in the other, culminating in *Tyrannosaurus,* giantism was attained during the Jurassic period, and from then on this was a line of giants.



Largest of the dinosaurs were the marsh-dwelling sauropods such as the upper Jurassic form *Brontosaurus*. Seventy or more feet in length, in life they must have weighed as much as 40 tons.

horned dinosaurs. Of these, the ornithopods retained to a considerable degree the bipedal pose of the primitive dinosaurs, but the other members of the order became quadrupedal. Giantism was prevalent, but none of the ornithischians became as large as the largest meat-eaters or, of course, as the giant sauropods. Without exception the ornithischians were herbivores.

Perhaps the most generalized of the ornithischians were the camptosaurs of upper Jurassic age. *Camptosaurus* was a small, bipedal dinosaur, comparable in size but not in structure or adaptations with the primitive meat-eating dinosaurs, described above. From a camptosaur ancestry the giant duck-bills evolved during the Cretaceous period. The evolutionary rate here was rapid, because by the beginning of upper Cretaceous times the duck-bills, such as *Corythosaurus* or *Saurolophus*, were beasts 30 or 40 feet in length, with body weights of several tons.

As contrasted with this evolutionary rate, the known rates of increase in the stegosaurs, or plated dinosaurs, and in the ankylosaurs, or armored dinosaurs, were comparatively slow. For instance, in the progression from *Scelidosaurus*, the earliest known stegosaur, to *Stegosaurus* itself there was a limited increase in body size occurring through a lapse of about 30 million years. The same was true in the sequence from *Polacanthus*, the earliest known ankylosaur, to *Ankylosaurus*, a late member of the group. It should be pointed out, however, that in these two phylogenetic lines of dinosaurs we do not have the earliest stages of evolution; the first known representatives in each line were already animals of considerable size. Without much doubt there must have been a comparatively short stretch of geologic time during which the earliest known genera of these dinosaurs evolved from small ancestors, following the same essential pattern of size increase that was developed in the evolution of the giant meat-eaters.

This pattern of evolution to giantism is very well exemplified in the history of the ceratopsians, or horned dinosaurs, which had their origin and went through their entire phylogenetic history within the compass of upper Cretaceous times. The first true ceratopsians appeared at the beginning of upper Cretaceous times in Mongolia. Here we find *Protoceratops*, a small ornithischian dinosaur about 6 or 7 feet in length with a probable weight in life of perhaps 80 or 100 pounds. Within the course of the next few million years most of the increase in size took place. *Monoclonius*, a large horned dinosaur from sediments not much later in age than those in which *Protoceratops* was found, was a dinosaur about 18 feet long, with a weight in life of several tons. From this point to the end of Cretaceous times, a matter of 20 million years or so, size increase in the horned dinosaurs was relatively not very pronounced. The last of the

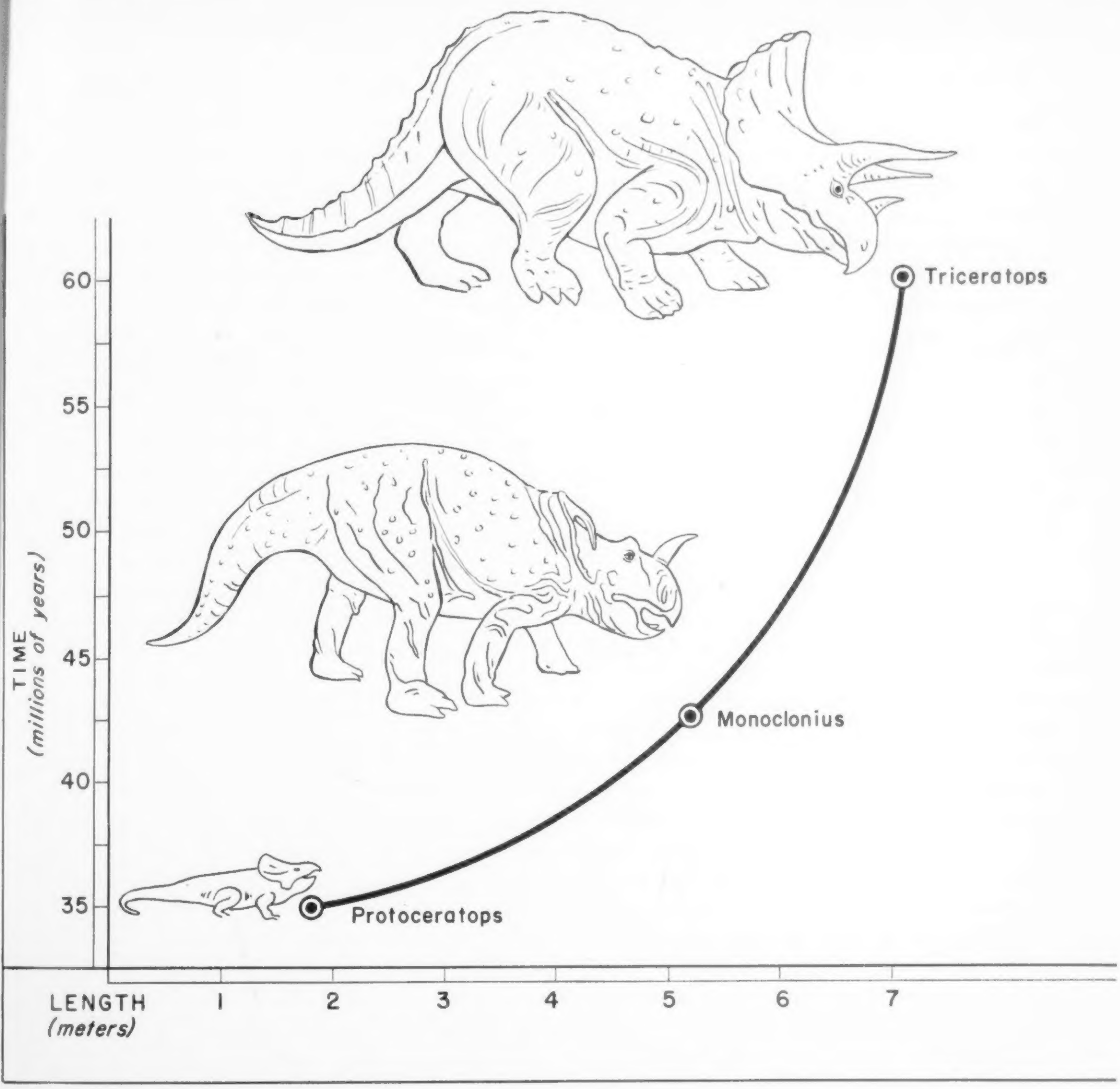
horned dinosaurs, such as *Triceratops,* were bulky animals a little more than 20 feet in length. Thus, in the history of the ceratopsians, which is well documented, there is seen the asymmetrical curve once again, rising rapidly and then tapering off in a long, gentle slope.

From the accumulated evidence there emerge certain facts regarding the evolutionary growth rates in the dinosaurs, and these can be briefly stated and reviewed. In the first place, it is evident that giantism was attained independently and at different times during the Mesozoic era by various lines of dinosaurian evolution. Certain meat-eating dinosaurs grew to great size during the interval between upper Triassic and upper Jurassic times, and the same was true of the herbivorous sauropods and the plated stegosaurs. The duck-billed dinosaurs followed the path to giantism in the interval between upper Jurassic and middle or upper Cretaceous times, and the armored dinosaurs became moderate giants during the same interval. Finally, the horned dinosaurs evolved as giants entirely within the limits of upper Cretaceous times.

Again, rates of size increase varied greatly in the different lines of dinosaurian evolution. Some were slow-rate lines, and others were fast-rate lines. Certain meat-eating dinosaurs were almost static in the rate of size increase, whereas other theropods showed a rapid rate whereby they evolved from small ancestors to giant end forms within the confines of a single geologic period. The giant sauropods, the ultimate in size among all land-living animals, attained their maximum dimensions at a comparatively rapid rate during Jurassic times. In the Cretaceous period the armored dinosaurs showed relatively little size increase, but the duck-billed dinosaurs evolved rapidly during the same interval. The horned dinosaurs, the latest dinosaurs to appear, also showed a rapid rate of evolution to giantism during the upper part of the Cretaceous period.

Finally, it is evident that the evolutionary rate,

Aquatic duck-billed dinosaurs were numerous and varied during upper Cretaceous times. Here is *Trachodon* along the shore of a Wyoming lake, perhaps 70 or 80 million years ago.



Increase in size through time of the horned dinosaurs. The increase from the small ancestral form, *Protoceratops*, to the giant, *Monoclonius*, took place at a relatively rapid rate. After that the increase to *Triceratops* was comparatively slow. (Illustrator's Corps, The American Museum of Natural History.)

so far as size growth is concerned, was not in the least constant within a single phylogenetic line. Rather, there was a marked variability in the rate of evolution, and this commonly followed a definite pattern. According to this pattern, there was an initial period of very rapid evolution, during which the developing line went through the greater portion of its size increase. After this there was a comparatively long stretch of phylogenetic history in which there was a limited size increase. To put it in another way, the evolving dinosaurs had a brief period of "growing up" followed by a "long life" as giants.

It is this long phylogenetic life of the dinosaurs as giant reptiles that is so impressive to the student of Mesozoic earth history. Most of the dinosaurs soon became giants, and as giants they dominated the earth for more than 100 million years. Evolution in the dinosaurs was largely a story of increase to large size, and for these ancient reptiles it proved to be a very successful pattern for long survival.

RECURRENT THEMES IN MEDICAL THOUGHT

ERWIN H. ACKERKNECHT

After receiving his M.D. at Leipzig in 1931, Dr. Ackerknecht held various medical positions in Germany and France. Coming to this country in 1941, he was a Fellow in Medical History at Johns Hopkins until 1944. He spent a year as curator of anthropology at the American Museum of Natural History before going to his present post as professor of the History of Medicine at the University of Wisconsin.

MEDICAL theories and techniques have changed tremendously during past millennia, and particularly during the past 150 years. Medicine's goal, however, has always remained the same: to recognize diseases and cure the sick. Medicine has thus never been a pure science like, for example, physics, chemistry, or physiology. As much as medicine has profited from the progressive incorporation of scientific elements, it remains essentially an art using the findings of a great number of sciences, and proceeding empirically in those cases where no sufficient scientific knowledge is yet available.

In applying the traditional term "art" to medicine I should like to make clear that it has nothing to do with the inspirational activities or commercialized neuroses that are now associated with this term. If we had to translate again today medical "art's" linguistic predecessor and equivalent, the Greek *techne,* we would be on much safer ground with the term "craft," a less poetical but eminently respectable notion, by no means excluding a sense of beauty and harmony. At the time of the original translation the arts and crafts still belonged together, and medicine was called an "art" just as were agriculture and architecture, two other utilitarian activities, at that time equally poor in scientific foundations, but acting successfully on the basis of solid empirical knowledge.

It is due to its peculiar character that medicine has always been more a field of action than reflection; nevertheless, at certain turning points of their history doctors have been compelled to extend their thoughts beyond the more immediate problems of their field, and to ask and answer a few basic questions, such as "How is medical knowledge best acquired?" and "What are the limits of medical knowledge?" A few of the significant answers given to these two questions in the course of medical history are here described and briefly discussed.

I

In the fifth century B.C. more and more Greek medical craftsmen began to base their practice on the notions of "hot, cold, moist, and dry" that had been singled out by the philosophers, the speculative scientists of that period, as the fundamental qualities of all matter. In the famous treatise *On Ancient Medicine,* one of the writers of the collection of medical books that has been attributed to Hippocrates arose against this theory and developed his own ideas on medical method. Medicine, according to him, has so far been based exclusively on observation. It has to remain this way, and has no need of any hypothesis:

> Wherefore I have not thought that it stood in need of an empty hypothesis, like those subjects which are occult and dubious, in attempting to handle which it is necessary to use some hypothesis; as, for example, with regard to things above us and things below the earth.

Whereupon the writer relates in a very elaborate hypothetical story how in his opinion medicine developed out of observations on diet. Although this rationalistic tale sounds very unlikely to us today, it is incidentally a good description of the inductive method.

No less hypothetical, in spite of his many fine observations, are this author's ideas that faulty diet causes all disease or that disease is the predominance of one of *his* basic qualities in the humors (bitter, salt, sweet, acid, sour, insipid). He adheres to one of the oldest and most tenacious hypotheses in biology, the teleological one, in regarding disease as an effort of nature to throw off the morbific matter by coction, etc., etc.

Practically, our Hippocratic antihypothesist seems thus rather more opposed to hypotheses made by nonmedical men ("scientists") than to all hypotheses. Among the former he also seems to count many aspects of anatomy:

> Certain sophists and physicians say that it is not possible for any one to know medicine who does not know what man is (and how he was made and constructed), and that whoever would cure men properly, must learn this in the first place. But this saying rather appertains to philosophy, as Empedocles and certain others have described what man is in his origin, and how he first was made and constructed. But I think whatever such has been said or written by sophist or physician concerning nature has

less connection with the art of medicine than the art of painting.

All the medical man needs to know—"what man is in relation to the articles of food and drink, and to his other occupations"—he can fortunately learn best and learn only through medical observation.

Our somewhat one-sided selections might make the Hippocratic writer look a less acute thinker than he actually was. His keen realistic insight into the practical limitations of medicine in his period when faced by certain ideal postulates is evident in his remarks on "quantitating":

For one must aim at attaining a certain measure, and yet this measure admits neither weight nor calculation of any kind, by which it may be accurately determined, unless it be the sensation of the body. We ought not to reject the ancient art [of medicine], as if it were not, and had not been properly founded, because it did not attain accuracy in all things, but rather since it is capable of reaching to the greatest exactitude by reasoning, to receive it and admire its discoveries, made from a state of great ignorance, and as having been well and properly made, and not from chance.[1]

The author of *Ancient Medicine* was a conservative, fighting a losing battle. Hypotheses like the "hot, cold, dry, moist" won, even in his own time, and for the next 2,000 years the field was most of the time dominated by some brand of dogmatist that placed theories, hypotheses, and real and fictitious results of other sciences above mere clinical observation. It is of the essence of dogmatists that they need not theorize why they are dogmatists. But those who revolted against dogmatism had to show why observations should prevail over theories and hypotheses. Their writings form, with a few exceptions, the bulk of medicophilosophical literature. Almost invariably these medical rebels and philosophical empiricists would now march under the awe-inspiring banner of "Hippocrates." Whatever the viewpoint of "Hippocrates," or even of the author of *Ancient Medicine,* may have been, they would take up more or less completely and consistently the points, abstracted above from *Ancient Medicine,* and show that the only healthy development of medicine would lie along the road of this "Hippocratism."

They thus became involved also in the same self-delusions and contradictions. While they fought hypotheses, they had all their own hypotheses and theories, for it is impossible to handle observational old or new facts for any length of time without these aids. Any approach toward solving medical problems—which are only specialized problems of general science—by nothing but unconnected medical observations, would sooner or later come to a dead end. And yet paradoxically enough, these philosophically and logically deficient movements are *landmarks of real medical progress.*

The first to rebel in this vein were apparently the "Empiricists" of Alexandria in the third century B.C. Unfortunately, our knowledge of them is scanty and indirect, stemming mostly from quotations in later writers like the Roman Encyclopedist Celsus (who lived around the beginning of our era) or Galen. But what little we know of them bears the unmistakable earmarks of our particular brand of "Hippocratism": their opposition to theory and hypothesis, their contempt for anatomy and dissections, their defeatism as to the possibility of knowing "hidden causes," and so on. They were soon outnumbered by dogmatic sects, and after Galen medicine was enveloped for 1,300 years in the rarely disturbed night of sterile Galenicist dogmatism.

II

In the Renaissance medical men not only produced a great mass of new observations in all fields of medicine—clinical, psychological, anatomical, and surgical—in this period also one of the most radical, most boisterous, most confused, and most gifted "Hippocratic" rebels entered the scene in the person of the strange Dr. Philippus Theophrastus Bombastus Aureolus von Hohenheim, called Paracelsus (1493–1541),[2] a contemporary of the Reformation and the German Peasant's War.

Hippocrates, the wayfarer, the man of observation, was the only medical author of the past that the revolutionary Paracelsus respected. Otherwise he despised ancient medical books and what they stood for to an extent that he could easily be credited with the legend of burning them publicly. Like other Hippocratists, he had no use for anatomy. He was somewhat more tolerant as far as theory goes, asking only that "not out of speculative theory should practice flow, but out of practice theory." (Nobody acted less according to this golden rule than Paracelsus himself.) Paracelsus the chemist—it is in this field that his immediate influence on medicine has been greatest—would allow chemical and astrological observation to be added to clinical observation. Paracelsus the mystic, still full of the all-pervading religiosity of the Middle Ages, is the only medical philosopher to have made God his fourth immediate source of medical knowledge. He was thus the father of what Marshall Clagett so aptly calls "iatrotheology."

The men of the sixteenth century had dealt heavy blows to ancient dogmatism, but the very discoveries of the young experimental sciences, chemistry and physics, became prematurely applied to medicine in the seventeenth century by the

iatrophysicists and iatrochemists, and thus formed the basis for new dogmatisms, no less deductive, stifling, and fact-distorting than the old. It was Thomas Sydenham (1624–89)—not incidentally an ex-captain in Cromwell's cavalry and a friend of John Locke—who raised the banner of the fourth "Hipprocratic" rebellion in the seventeenth century. His scorn for all medical literature except the works of Hippocrates is clearly expressed in his recommendation to a medical student who had asked him what books to study: "Read *Don Quixote*." He had no use for physics and chemistry, not even for the new anatomy and physiology. Clinical observation again is the sole and only foundation. Hypotheses are worthless. It is, as he repeatedly states in the prefaces to his *Medical Observations of Acute Diseases*, impossible to find the "final causes" of disease. Etiology is essentially inexplicable. Thus treatment has to be derived from the observation of symptoms.[3]

Actually Sydenham abounds, of course, not only with fine clinical observations, but also with doubtful theories. He maintains not only the old Hippocratic teleological "coction" of humors as an effort of nature to overcome disease, or develops Hippocratic clues into his vague theory of "epidemic constitutions," but he creates such un-Hippocratic notions as the classification of diseases into species like plants and animals, or the striving for an automatic *methodus medendi*. Actually, also, Sydenham is another case of split personality, theorist and antitheorist in one. In this respect some historical injustice has been done to many of his iatrochemical and iatrophysical contemporaries such as Willis, Sylvius, or Baglivi. Their dogmatic utterances and Sydenham's antitheoretical declamations have, especially in more recent times, both been taken too much at face value. These men, too, were split personalities, in their case hiding first-rate clinical qualities under the cloak of dogmatism. Although Sydenham undoubtedly was a great clinician, he was only one of many great clinicians in the seventeenth century. True Hippocratism never dies out among really good doctors, fanciful as may be the theoretical notions that they embrace.

III

The common man's hopes for freedom during the Reformation had come to nought. Absolutism in its crudest forms followed the great awakening. A similar situation prevailed in medicine, where the "systems" ruled sovereign during the seventeenth and eighteenth centuries. The same great French Revolution of 1789 that wiped out absolutism was followed by a medical revolution that wiped out the "systems." This revolution gave France world supremacy in medicine for half a century,[4] bringing into being the great French clinical school, also called the pathologico-anatomical school, or the "school of observation." This French school represents the fifth of our "Hippocratic revolts," and is, for that matter, the most consistent and most successful of all.

Like the political revolution that had been preceded by a revolutionary philosophy, the "medicine of observation" was preceded by a medical "philosophy of observation" which is usually connected with the name of the ideologue P. J. G. Cabanis, a follower of the sensualist Condillac.[5] Among those who put this philosophy of observation into practice, at least the leading group of the Paris school (G. L. Bayle, Laennec, Chomel, P. Louis) shows the well-known fundamental tenets of earlier "Hippocratic revolts."[6] Observation is the exclusive foundation of medical science. Therefore, among the authors of the past only the observer Hippocrates (and possibly Sydenham) deserve consideration. The following quotation from Laennec, the inventor of the stethoscope and auscultation, shows the typical aversion to hypothesis and theory, and the usual defeatism as to the possible elucidation of causes:

> I shall not here attempt with the nosologists to divide the diseases of which I propose to treat into genera and species. . . . I shall still less endeavor to ascertain the primary, or as they are called, proximate causes of diseases. The vanity of researches of this kind is sufficiently proved by the profound oblivion into which all theories of this nature have successively fallen. I shall content myself with describing the disease of the thoracic organs. . . .[7]

This attitude toward theories is also reflected in Laennec's definitions of medical science: "Only the facts constitute science." "Theories in science must be regarded as aids to memory. They do not constitute science." The logical outcome of this attitude was P. Louis' "Numerical Method" (clinical statistics). If you can't reason about facts, you can at least add them up and divide. Neither chemistry, nor the animal experiment, nor the microscope was used by this school.

In order to understand why it nevertheless was so conspicuously successful—far more successful than all its predecessors—we must realize that the "observation" it practiced was no longer merely the passive observation of symptoms that constituted almost the total observation of the past. Using the new methods of auscultation and percussion, the Paris doctor of the 1820s no longer only "observed" the patient, he "examined" him.[8] He furthermore checked his observation with the

findings at the autopsy table. There he found the anatomical lesion, which now became his point of reference, instead of vague symptoms. And all this he did, not on the small scale of a rural practice, but on the "industrial" scale of the large hospitals of the big city.

Still, even this school, which opened a new world to medicine, suffered from the same contradictions as its empiricist predecessors, and it ended in a blind alley when its technical and philosophical limitations caught up with it. It was the last of the great empirical movements in medicine. The scientific and philosophical foundations on which its successor, appearing under the label of "physiological" or "experimental" medicine, built have now lasted for more than a hundred years. Not that the older ideas are dead; but our fundamental concepts have not been seriously shaken by the "neohippocratic," "neosydenhamian," "neoparacelsian," and "neolouisian" attempts of the past three decades.[9]

The finest philosophical exposition of modern medicine is still Claude Bernard's *Introduction to the Study of Experimental Medicine* (Paris, 1865). Bernard gave us a proper attitude toward hypothesis that is controlled through the experiment. He gave a real philosophy of the experimental method, which is more than just experimenting. He relieved us of the old sterile dichotomies between empirical and scientific medicine; induction and deduction; observation and experiment. His notion of the internal environment was an important attempt to bridge the contradictions between mechanism and vitalism, determinism and free will.

The solutions provided by Bernard and his contemporaries were possible only on the basis of the great amount of newly acquired actual knowledge. A more correct philosophy was found only when a reality had been created that corresponded to it. Before, occasional guesses as to such solutions were possible, but they could be consistently maintained only to the extent that they could be applied. Now that we know at least *something,* we have also for the first time become able to face the whole magnitude of our ignorance. The confidence of former generations in the mere figments and fragments of knowledge they possessed is touching, psychologically understandable, and was probably necessary; yet there is no doubt that such delusions would also play a retarding role in the progress of knowledge.

Such discussions of the medical and scientific thought of the past as we have indulged in will probably seem superfluous to many "practical" scientists. Yet the problems that provoked our forefathers do still exist, although perhaps on a higher level. And it cannot be hoped that even Bernard's philosophical solutions will have permanent validity. The best proof for the necessity of such discussions lies in the amazingly unscientific attitude shown by just such critics (often great scientists) if they are faced by any problem lying outside the limits of their often very narrow specialty. The inability of many scientists to approach problems outside their specialties in a scientific way (unemotionally, objectively, critically, quantitatively) is the consequence of the fact that they have never become conscious of the philosophical premises of their own work by comparing them to other possible premises. This failure of scientists is a tragedy. Science could contribute more to humanity than refrigerators, or vitamin pills, or atomic bombs if scientists would not only make science, but, in the footsteps of so many of their greatest, also think of it. It might even help them in making science.

NOTES

1. The Hippocrates quotations are taken from *The Genuine Works of Hippocrates,* translated by Francis Adams. New York: 1886, Vol. I, 132, 143, 136, 138.
2. The only available English Paracelsus translation is the *Four Treatises of Theophrastus von Hohenheim called Paracelsus* (H. E. Sigerist, Ed.), containing the "Seven Defensiones," translated by C. Lilian Temkin, which are particularly relevant to our subject. Baltimore: 1941.
3. See especially *The Works of Thomas Sydenham,* translated by R. G. Latham. London: 1848, 16, **4**, 14, 18, 20, 72, 16.
4. This French supremacy is not limited to clinical medicine. It extends to numerous other sciences—and hygiene. See Ackerknecht, E. H. Hygiene in France 1815–1848. *Bull. Hist. Med.,* 1948, **22**, 117 ff.
5. Concerning the philosophy of Cabanis see the two following excellent papers: Temkin, O. The Philosophical Background of Magendie's Physiology. *Bull. Hist. Med.,* 1946, **20**, 10 ff.; Rosen, G. The Philosophy of Ideology and the Emergence of Modern Medicine in France. *Bull. Hist. Med.,* 1946, **20**, 328 ff.
6. For a detailed analysis of the philosophy of the Paris school see the forthcoming article of E. H. Ackerknecht, Elisha Bartlett and the Philosophy of the Paris Clinical School. Elisha Bartlett's *Essay on the Philosophy of Medical Science* (Philadelphia, 1844) is the only contemporary systematic exposition of this French medical philosophy.
7. Laennec, R. T. H. *A Treatise on the Diseases of the Chest.* New York: 1835, 60. (First edition, Paris, 1819).
8. Faber, K. *Nosography in Modern Internal Medicine.* New York: 1923, 36.
9. The following interesting article uses also analyses of the five movements described above, though from a different point of view: Guttentag, O. E. Trends Toward Homeopathy, Present and Past. *Bull. Hist. Med.,* 1940, **8**, 1, 1,172 ff.

THE SEVENTH PACIFIC SCIENCE CONGRESS

ROBERT CUSHMAN MURPHY

Dr. Murphy sits in the world's only endowed chair of ornithology. He is Lamont Curator of Birds and chairman of the Department in the American Museum of Natural History. Dr. and Mrs. Murphy have spent the past two winters in New Zealand, engaged in part in excavating the remains of moas and other extinct birds. In 1949 they were both accredited delegates to the Seventh Pacific Science Congress.

FOR members of the delegation of the National Research Council an unforgettable aspect of our New Zealand experience was the flight from Washington in a plane of the United States Military Air Transport Service. The principal object of Captain Gratton C. Miller, in command, seemed to be to gratify the curiosity of his scientific contingent, even to the extent of minor departures from course. Most thrilling of several such opportunities was an ascent to 17,000 feet above the then active crater of Mauna Loa on the island of Hawaii. Making loops or figures of eight, the craft passed three times directly over the *caldera* so that we could watch the fountain of molten lava welling up at least two hundred feet above the orifice, spilling over as a "waterfall" into the smaller South Crater, and thence flowing down the slope in three great fingers, each with a glowing axis.

On the opposite, or southern, side of the *caldera* we saw the cold black lava of a former flow which had threatened Hilo, but which had been thwarted by Army bombardiers who smashed the hardened tube through which fiery fluid was pouring, thus diverting the stream into an uninhabited valley.

All this private view of the world's greatest insular volcano was accompanied by a running commentary by Dr. Donald E. White, the official volcanologist of our group, and by the botanist Dr. F. R. Fosberg, who knows the island of Hawaii with particular intimacy.

A second bit of unscheduled scouting came in Fiji, where our plane hedgehopped over the emerald wilderness of Vanua Levu, giving us glimpses of hidden valleys and lakes, unmapped peaks, and scattered Melanesian villages.

Previous congresses in a series unduly interrupted by the war had been held in Hawaii (1920), Australia (1923), Japan (1926), Java (1929), British Columbia (1933), and California (1939). The New Zealanders, taking over a responsibility that the war-battered Filipinos had been obliged to defer, extended invitations for February 1949 to forty-eight countries and to several international agencies, such as appropriate commissions of the United Nations. The Seventh Congress was launched at Auckland on February 1, the date of our arrival, with an evening reception given by the Mayor of the City—"His Worship" rather than His Honor.

AUCKLAND SESSION

The opening of the scientific sessions in Auckland University College on February 2 saw an impressive gathering of nearly five hundred delegates from New Zealand and countries bordering the Pacific, as well as from Great Britain, France, and the Netherlands, which have historical and national ties with extensive Pacific areas. The three Scandinavian nations, all of which have conducted scientific work of high significance in the Pacific Ocean, were also represented. The chairman of the Norwegian delegation somewhat whimsically remarked that his country actually has a Pacific possession; he thereupon invited the audience to locate Peter First Island without scrutinizing a map.

The chairman of the Swedish group, Dr. Carl Skottsberg, an authority on island plant relationships, noted that his own country is about as far from the Pacific as it is possible to travel. "On the west," remarked Dr. Skottsberg, "Sweden is separated from the Pacific by another ocean and a continent. On the east it is blocked off by a vast territory in which the present climate is so unfavorable that international highways have been closed."

Incidentally, the USSR had not replied to the invitation of the Royal Society of New Zealand to participate in the congress. Hawaii, on the other hand, was present as formerly in the full stature of a "nation." Dr. Peter H. Buck (now Sir Peter Buck, known in New Zealand as Te Rangi Hiroa because of his Maori origin), director of the Bishop Museum in Honolulu, and chairman of the Hawaiian delegation, remarked somewhat wryly

that he failed to understand why Americans did not universally view Hawaii as one of the states of the Union when the rest of the world, at least as exemplified by Pacific Science Congresses since 1920, obviously granted it the status of a sovereign country!

Such comments from the chairmen of the various national delegations were characteristic of the humor that accented the completely serious tone of replies to the gracious New Zealand welcome extended by Dr. Robert A. Falla, president of the congress. A state of enthusiasm was reached when the Philippine delegation, appearing for the first time as spokesmen for a new republic, requested the members and participants to make the Philippines the site of the Eighth Pacific Science Congress. This invitation of Dean Antonio G. Sison, of the Medical College at Manila, was subsequently accepted, though without the designation of a date, which probably will be set within the next two years. The ravages of war had compelled the Republic of the Philippines to yield its place to New Zealand; cheering therefore greeted Dr. Sison's description of the valiant work of reconstruction that will fit the ancient capital to serve as host for the Eighth Congress.

It was interesting to note that all delegates, including those from the Philippines, the East Indies, and Scandinavia, spoke in English, with the exception of the French representatives from Europe, Indo-China, or the Pacific possessions, all of whom used their own tongue.

The inaugural assembly was followed by meetings of the ten separate sections of the congress, each of which proceeded into its scientific agenda as soon as the organization details had been attended to. These sections were: Geology and Geophysics; Meteorology; Oceanography; Zoology; Botany; Soil Resources, Forestry, and Agriculture; Anthropology; Public Health and Nutrition; Social Sciences; Organization of Research. A glance through the eighty-six printed pages of the general program showed a strong coordinating tendency among the various scientific disciplines. Zoology and Botany, for example, combined part of their sessions with Oceanography, part with Agriculture, and there were many other liaisons exemplified by anthropological, medical, and social sciences, etc. In the admirable organization of the congress the energy, skill, and tact of Dr. Gilbert Archey, who had accepted the arduous post of secretary-general, have been evident from the beginning of negotiations in 1947 to the completion of responsibilities still under way.

It scarcely needs to be pointed out that problems requiring international scientific cooperation are especially suitable for assemblies marked by a geographic limitation. Much of the New Zealand program dealt with fundamental science, as might be expected from the stated aims of the Pacific Science Congresses—as well as from representatives of research in the native land of Lord Rutherford. At the same time, lay followers of the proceedings occasionally needed reminding that basic subjects, such as mathematics, were in large measure excluded by the geographic scope; and that even physics and chemistry entered chiefly as the handmaidens of seismology, meteorology, biology, etc., as these related to Pacific areas. Such facts always create difficulties for a program committee. It is even to be suspected that here and there the phrase "with special reference to the Pacific" was tacked onto the end of a title with the object of dragging it into the regional paddock!

Both morning and afternoon sessions were regularly interrupted for general gatherings at tea, and in this respect all the visitors seemed rapidly to become inveterate New Zealanders. The evenings were devoted to public lectures, of which the first, entitled "Leaves from a Plant Collector's Diary," was given by Professor Knowles A. Ryerson, of the University of California, chairman of the American delegation. A lecture on the evening of February 3 by Te Rangi Hiroa burst the seams of the largest available hall in Auckland, so that the doors had to be shut against hundreds still seeking admission. This was a tribute not only to Dr. Buck's intellectual vigor and sprightly speech, but also to the fact that, as anticipated, he lifted the roof with an ancestral Maori chant before he left the platform. His lecture, which was illustrated by a documentary color film, related to Kapingamarangi, an atoll south of Truk in Micronesia which, surprisingly, is inhabited by purely Polynesian people whose language differs only dialectically from Dr. Buck's native tongue. The lecturer was officially thanked by the elderly statesman Sir Apirana Ngata. Although a rock-ribbed conservative, who has not espoused the Labor cause along with most of his Maori people, Sir Apirana is universally admired for his character and his pungent oratory.

Other interruptions in what might have become a too-tense experience in scientific concentration came in the form of afternoon parties in the open air among well-nigh peerless New Zealand gardens, which were at this date at the height of their luxuriance. Furthermore, we were all looking for-

Presidents, veteran and new. Prof. H bert E. Gregory, president of the ori nal Pacific Science Congress at Ho lulu, in 1920; and Dr. Robert A. Fa president of the Seventh Congress.

Delegates from overseas. Athelstan F. Spilhaus, University of Minnesota; Wang Ging-Hsi, UNESCO; G. E. R. Deacon, Admiralty Research Laboratory, England; Patrocinio Valenzuela, University of the Philippines.

Informal conference between Professor G. W. Robinson, agricultural chemist and chairman of the British delegation, and Mr. Charles W. Fleming, New Zealand geologist.

Visiting the camp of the New Zealand-American Fiordland Expedition, where long-term investigations on the effect of introduced deer upon native "bush" are in progress. Col. J. K. Howard, of Boston, organizer, is third from the right; at the left end is Dr. Olaus J. Murie, of Wyoming, scientific director.

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ward to the intersessional and postsessional tours that subsequently transported visitors, as guests of a generous government, to many of the famous regions of natural charm in New Zealand, including the thermal districts, the mountains, glaciers, and national parks.

By the middle of the first week, the number of delegates from overseas had passed two hundred, the largest representation in the history of the Pacific Science Congresses. The total attendance was next in size to that of the Sixth Congress in San Francisco, ten years ago.

Important as were the scientific meetings at which contributions were presented and discussed, the contacts and informal chats with colleagues from other lands offered perhaps the most important opportunity of all. During the first day or two, visitors from the United States and Canada made many literal "contacts" with their New Zealand confreres in some of the narrow corridors of Auckland University College. The overseas men instinctively turned to the right, the New Zealanders, of course, to the left. As one of our own group remarked, the American expression "I'm glad I ran into you" acquired a new significance!

For lack of a sufficient cooling-off period after the bitterness of war, the Japanese had not been permitted to send their nationals to this congress, a fact regretted by many. A few of those present remembered happily the Third Congress, at Tokio, in October and November, 1926. All who flew from Japan to New Zealand were Americans who came by authority of General MacArthur, the Supreme Commander for the Allied Powers. Most of these delegates, however, brought with them manuscripts by Japanese scientists and presented them on behalf of their authors. There were, indeed, about one hundred fifty contributions by Japanese, and it is noteworthy that they were as well received and as freely discussed as any of the others.

USE AND MISUSE OF NATURAL RESOURCES

New Zealand, as a prevailingly agricultural and pastoral country, lives and exports mainly from the soil, and its citizens have a keen eye for applications of science that will directly enrich their resources or accomplish the same end indirectly by slowing down the rate of exploitation. Conservation was, indeed, the keynote of many papers in practically every section of the congress program, indicating a realization of the fact that all the modern world is living largely upon the capital rather than the interest of natural wealth. A Dominion that aims to send a thousand tons of food a day to Great Britain in addition to maintaining a high level of subsistence for its own population was, of course, interested in learning of food supplies not yet significantly tapped. Deep interest was expressed in a report to the congress by Dr. J. L. Kask, of the Food and Agriculture Division of the United Nations Organization, to the effect that the Pacific, the largest of the world's oceans, yields only a third of the total marine fish catch of the world, and that of this small proportion less than 5 percent is taken from waters south of the equator.

Resolutions adopted at the final plenary session reveal the deep concern of visitors and native sons alike in the status of New Zealand soils, water tables, and plant cover, and in the role of introduced organisms. Many of the last-named have long been acknowledged pests; and yet the feeling was expressed that New Zealanders seem to have difficulty in making up their minds—permanently—as to when vermin is vermin and when it is not. Rabbits, for example, suffer the enmity of agriculturalists while enjoying the favor of dealers in meat and pelts. (They thrive on both!) Few of the foreign delegates, despite the briefness of their experience, had any doubt about the curse of alien animals. They at least had the backing of an able New Zealand forester, Dr. Holloway, who stated forthrightly that it would be impossible for the Dominion to keep both introduced deer and native beech (*Nothofagus*) forests, and that the decision as to which of the two is wanted forever is strictly a home problem.

Although there was a certain diversity of opinion regarding the implications of soil erosion, all visitors emphasized its seriousness. Professor G. W. Robinson, chairman of the British delegation and a renowned expert, held a relatively hopeful outlook, whereas others, such as Mr. Ernest G. Holt, of the American Soil Conservation Service, regarded the present damage in certain areas as the worst they had ever witnessed in temperate lands, and amenable to repair only through prolonged and unflagging labor involving the re-establishment of dense plant cover on hilltops and upper slopes.

In science as applied to farm life, New Zealanders have long been pioneers and leaders. For example, the "progeny test," originally advocated in Denmark as a technique of judging and breeding livestock, has been carried to its logical conclusion in the sheep runs and cattle pastures of New Zealand. The method implies that in com-

petition a domestic animal, such as a ram or a milch cow, is judged not merely on its conformation, ancestry, and "blue-ribbon look," but even more upon the character of its offspring. This means that at New Zealand fairs the best-looking animal is by no means sure of first prize. It may, and often does, lose out to another that has produced a superior line of descendants. In short, "handsome is as handsome does." The real criterion of excellence is not what the creature appears to be, but what it begets. In the United States, there is still opposition to this point of view among breeders because many owners and exhibitors incline toward prejudice in favor of the most sleek, becurled, and beribboned entry in the stock show, and are ready to assume that such will likewise produce posterity of equal worth. New Zealanders are more hardheaded and empirical. American delegates taking part in the section of Soil Resources, Forestry, and Agriculture were vitally interested in the progeny test and in evaluating the results as they found them at the agricultural institutes of both North and South Islands.

SCIENCE AND SOCIAL RESPONSIBILITY

Among participants in the congress, the anthropologists were perhaps represented in largest force. They also seem to have had a particularly lively time. The content of many papers in this comprehensive field indicates a new spirit in the world with respect to what used to be called "subject peoples." The general theme of the earlier anthropological sessions was announced as "Administration and welfare, including contemporary cultural changes among Pacific island peoples."

No longer, it appears, are the bigwigs of administration wont to assume that the fewest suggestions and the least interference from any outside source will enable them to accomplish the most acceptable job. On the contrary, most of those charged with the responsibility of governing have grown humble; they crave, and even pay for, the wisdom that may issue from specialized research. It is surely symbolic that, when Professor Ernest Beaglehole criticized aspects of his own government's regime in the Cook Islands and Western Samoa, the Prime Minister of New Zea-

Evergreens two hundred feet tall. New Zealand has all too few remaining stands of its half a dozen kinds of huge podocarps, relatives of the yew. These trees, at Inangahua, are *kahikateas,* or "white pines" (*Podocarpus dacrydioides*).

land merely turned the other cheek, stating to reporters that Beaglehole's paper would be studied by the Island Territories office "with a view to translating such criticism into beneficial administrative action."

Beaglehole said that the contrast between self-government and good government is much more obvious in the capitals of world powers than it is among Pacific dependent peoples. Good intentions, together with self-interest, frequently delay recognition of the fact that a colonial people may be fitted to govern itself, even though the level of government thus attained may not be as efficient as imposed government. But inherent progress is more important than mere orderliness. We must remember, he stated, that in homogeneous island societies the residents' wants are often easily met, provided they obtain them in their own way and place and time. Self-government for such societies is likely to be more satisfactory in the long run than any type of imposed government. Administrators should be expected to draw more than in the past upon the insights and techniques to be derived from contemporary psychology and anthropology.

Americans listening to the opinions of this New Zealand scholar could not help but rejoice that the Philippines had been turned over to their own people on the due date, regardless of the temptation to delay because of the international turmoil in the Pacific.

The outmoded missionary notion of completely supplanting original customs by provincial *mores* of the white man is, of course, anathema to current points of view, religious as well as scientific. Sir Peter Buck, always a wag, remarked during one of the discussions that the former insistence upon covering nudity had more or less faded out of the Pacific island picture because present-day whites are "outstripping the natives."

NORTH ISLAND AND SOUTH

Between the citizens of the two large islands of New Zealand an old and healthy rivalry leads to bantering similar to that of the Floridians and Californians. The way to make a North Islander froth at the mouth is to tell him that you have just crossed Cook Strait from the "mainland."

Before the delegates of the Seventh Pacific Science Congress left Auckland for the concluding session at Christchurch, the North Island itself seemed to take a hand in the striving for popularity. The last sunset at Auckland, for example, was marked by a magnificent rainbow over the Gulf of Hauraki. The first evening at Wellington, the capital put on a welcoming display of the aurora australis. Over the ocean to the south the sky was a red and orange glow, against which the Kaikoura Mountains, across Cook Strait, stood out in livid silhouette, and a ghostly gleam tinged the landscape about us, suffusing even the grass at our feet.

These phenomena, however, were only a small sample of the North Island's bag of tricks. During the southward series of tours, in which all overseas members of the congress participated, the routes of the buses carrying botanists, meteorologists, anthropologists, etc., converged at Rotorua, in the thermal district, where the geysers and fumaroles put on the best show known for months past. Not to be outdone, Mount Ngauruhoe, one of the triple volcanoes in the Tongariro National Park, west of Lake Taupo, went into violent eruption after a long period of quiescence. The visiting volcanologists, of course, climbed the mountain even beyond the zone of safety. Several larger parties were driven to points of vantage as close as six miles from the cone, where for two or more days and nights they saw the fiery halation around the rim and watched house-sized rocks being shot into the air to heights of 1,500 or 2,000 feet above the crater, all to the accompaniment of earth rumblings and gargantuan machine-gun fire.

The larger neighbor of Ngauruhoe, Mount Ruapehu, discreetly remained seen but not heard, no doubt because it had put on its own exhibition with considerable fury only two years ago. A lasting impression for many of the visitors was that of the pink-flushed snowfields of Ruapehu, looming up above 9,000 feet and seen at evening of the last day in North Island across fifty or sixty miles of lowland.

Finally, at Wellington we were served with a very comfortable little earthquake, which made our beds quiver thrice as a prelude to the arrival of early-morning tea.

A notable experience for all members of the anthropological party and many of the other visitors was the welcome arranged by the communities of Maoris for the distinguished representative of their own blood, Sir Peter Buck, who had not previously returned to his native land for many years. The bulk of the Maori people still resides in the North Island, as in primitive times, and at each center ancestral tribal celebrations were staged for the homecoming, at which ancient costumes, ritual dances, and Polynesian chants and feasts all had their part.

Where else but in New Zealand could delegates to a science congress reach the nests of albatrosses by motor? The author at Taiaroa Head, the tip of Otago Peninsula.

CHRISTCHURCH, AND THE ZOOLOGICAL PROCEEDINGS

From Wellington the visitors traveled by steamer to Christchurch, most English and Anglican of all New Zealand cities. The time of arrival was before breakfast of February 16, and yet by mid-morning everybody was thoroughly absorbed, in halls around the Gothic quadrangles of Canterbury College, in the smooth continuation of the scientific program that had been broken off more than a week earlier at Auckland.

A new and invigorating feeling was in the air. Summer days at Christchurch can be hot, but the city and its environs rarely or never experience the subtropical weather that is characteristic of low-altitude areas in North Island. At any rate, we were particularly favored, for the days were both sunny and crisp, and at night the temperature even fell slightly below frost. The sparkling air and fresh breezes of morning were well calculated to arouse the time-honored Anglo-Saxon sentiment, "It's a fine day; let's go out and kill something." Suffice it to say that this urge was sublimated by scientific debate!

Of the Zoology Section of the congress, faithfully attended by the writer at both Auckland and Christchurch, space will permit reference to only a few aspects that have special bearing upon the New Zealand region.

Dr. G. E. R. Deacon, of the British *Discovery* Committee, set the stage with a paper on "Surface Boundaries in the South Pacific Ocean." This treated of the more or less fixed lines known as "convergences," where circumpolar bands of antarctic, subantarctic, subtropical, and tropical water come into contact, delimiting zones comparable with the better-known climatic belts on the continents. Deacon elucidated the hydrostatic origin of the convergences, based upon the prolonged investigations of the *Discovery* and other recent oceanographic expeditions.

The term "boundless deep" is a purely poetic concept. We now know that sea water is not homogeneous, like water shaken in a bottle; on the contrary, it is stratified and stable. Masses of differing temperature and salinity do not mix readily, even at the wind-blown surface. They retain their separate physical and chemical characteristics, which limit in turn the distribution of marine organisms. The control is, indeed, as thoroughgoing as that imposed on the land by barriers such as mountain range, river, "bush," or desert.

It so happens that the convergence separating subantarctic from subtropical ocean water in the Pacific cuts across New Zealand near the latitude of Cook Strait. The effect of the two zones upon animals and plants living within the sea, and also upon aerial creatures such as the marine birds that feed upon them, has long been familiar to Dominion naturalists. Dr. Deacon's report was therefore followed by lively commentaries, in the course of which new information was brought to light.

If there is science in the modern exploitation of whales—sometimes incorrectly called an "industry"—it surely belongs in the applied category. Nevertheless, the companies engaged in whaling operations can render priceless service to scientific investigators. In the long run, this is also likely to redound to their practical benefit. A good illustration was offered in the report by Mr. W. H. Dawbin and Dr. R. A. Falla on the life history of the humpback whale, based upon studies made at the commercial station in Tory Channel, New Zealand. Inquiry into the migrations, probable routes, population, ratio of the sexes, time and rate of reproduction, growth, and the alternating periods of feeding and abstinence yielded enlightening data for integration with findings in other areas of the world ocean.

A related though more general study by Dr.

N. A. Mackintosh, of the *Discovery* Committee, revealed that the humpbacks, unlike other whales, tend to segregate themselves in several restricted antarctic areas. There is little doubt, Mackintosh believes, that the humpbacks captured in New Zealand waters come from Area V in the far south, that is, from the waters between longitudes 130° E and 170° W. The pelagic whaling factories have thus far scarcely touched this Pacific sector, a fact which may presage a satisfactory picture for the New Zealand catch if it is conservatively handled.

The author on a three-day hike from Milford Sound through the alpine pass to Lake Te Anau, known to New Zealanders as "the finest walk in the world."

Overseas migration of birds was the subject of several contributions of a more maritime than terrestrial nature. It was discussed in papers read on behalf of two Americans, Dr. Rollin H. Baker and Dr. Ernst Mayr, neither of whom was able to attend the congress, and in another report by Dr. D. L. Serventy, of Australia.

Large numbers of northern Asiatic birds winter each year among the islands of the Pacific. Every New Zealander is acquainted with the godwit, for instance, or at least with the stories and legends applied to it. The more distant an island is from the coast of Asia, the fewer wintering species it possesses. A less spectacular annual migration, but one that still involves more than twenty-five different kinds of birds, proceeds from New Zealand and Australia northward. Both these types of migration can be explained on the basis of orthodox theories in combination with the familiar phenomena of route abbreviation and prolongation. There is no advantage to be derived, in Mayr's opinion, from dubious geological hypotheses, such as that of continental drift. Migration is necessarily one of the products of evolution, and flights to tiny and isolated atolls of the central Pacific, such as are made by the New Zealand long-tailed cuckoo, can be readily comprehended if it is assumed that such islands are remnants of once more extensive volcanic archipelagos, now submerged. Such a "stepping-stone" theory is far more credible than one based upon a Pacific continent that has subsided beneath the waters.

A notable place in the program of the congress was taken by women. The greater proportion of these, naturally, were New Zealanders, but Australia, the East Indies, Hawaii, the continental United States, and several European countries were likewise represented. Since yet unutilized oceanic food resources received so much attention, a large assembly heard the presentation of a paper on "Problems in Fisheries Management for Pelagic Schooling Fish," by Dr. Frances N. Clark, of the California Bureau of Marine Fisheries. Another American woman who took effective part in the discussions was Professor Carey D. Miller,

Hunting the long-departed. A glimpse of excavations for moa skeletons at the famous Pyramid Valley Swamp in North Canterbury.

Te Matua Ngahere, "the father of the forest." This tree, fifty-three feet in circumference, was believed to be the largest surviving *kauri* in the Waipoua State Forest. Recently, however, a still bigger one has been discovered.

In a latitude corresponding with that of Montreal, the New Zealand "bush" resembles a tropical rain forest, with abundant lianas, orchids, and cryptogams, including an amazing wealth of ferns.

of the Department of Nutrition, in the University of Hawaii.

AFTERTHOUGHTS

It was a source of surprise and regret that the Latin-American republics bordering upon the Pacific sent no scientific delegates, but confined their representation to the nominal appointment of diplomatic officers. This is hard to understand in view of the ready participation of such countries as Chile, Peru, and Mexico in similar scientific conferences within the Pan-American region and in Europe. The feeling was expressed that Peru, which has developed the largest undertaking in the world based wholly upon the conservation of wild animals—i.e., the guano industry—would have had much to add to deliberations on natural resources and agriculture. It is hoped that means may be found for persuading our southern neighbors of the mutual advantages to be derived from sending delegates to the Eighth Congress in the Philippines.

There was something peculiarly warming and altruistic about our experience in New Zealand. As Dr. Falla remarked, monographs, textbooks, and names suddenly became faces and voices and handclasps. An international political meeting, however statesmanlike and well-intentioned, is likely to be bedeviled by nationalism and undue watchfulness. Here among the scientific men and women there was no reigning idea other than the free exchange of data and the pursuit of truth, all in relation to the betterment of the world in which we must somehow contrive to get along together.

The congress, by the way, was perhaps the first general scientific meeting at which problems of human population in relation to the ultimate possible productivity of soil and sea were squarely faced. In the memorable symposium on "The Social Implications of Science," as well as in various sectional meetings, present and impending population trends of man—by far the most abundant, and the only rapidly increasing, species of large vertebrate animal—were stimulatingly discussed.

Press coverage in New Zealand was accurate, dignified, and sympathetic, in both the news and the editorial columns. If the sideshows of journalism, such as cartoons, quips, and verse, are sometimes a better gauge of genuine popular interest than even the best of reporting, the congress fared well on that score also. We were all the happier for the compliment of a little good-natured lampooning. We had a glorious time; we shall not forget what New Zealand has given us of both information and inspiration, and of bountiful hospitality.*

* Reports on the congress already published include the following:

SIR NORMAN HAWORTH. Science and Development in the Pacific Area. *Nature,* March 26, 1949, **163**, 469–72.

R. C. MILLER. Flight into Tomorrow. *Pacific Discovery,* March–April 1949, **2**, 18–21.

GRACE E. B. MURPHY. Scientists Scan the Unknown Pacific. *New York Herald Tribune* (editorial page), January 31, 1949.

GRACE E. B. MURPHY. The Pacific Science Congress, *idem,* March 13, 1949.

K. A. RYERSON. The Seventh Pacific Science Congress. *Science,* May 27, 1949, **109**, 529–33.

MAN'S MOMENT

Leslie A. White

Midnight,
Vast vapors spread through space,
Infinite, thin, nebulous.
Dawn approaches,
The Cosmos stirs in her sleep.
The vapors sigh, coagulate.
Clouds gather, shift, and part;
Galaxies begin slowly to revolve,
Their spiral arms closing
In rotational embrace.
Heat and light and rays unknown
Pass like whispers from star to star.

Morning comes,
And on a tiny speck,
An infant of a modest star,
A ferment starts.
Swimming about, then crawling;
Climbing and chattering in the trees;
Through a bright morning hour
Man struts about,
Wondering, building, fighting,
Viewing the Cosmos through himself:
"All this for me!" he cries.

Morning wanes,
Civilizations grow old and die.
Man comes of age at last,
But as his grasp extends
He clutches ever less.
His conquest of the Earth
Robs him of his mastery
And leaves him but a tenant
For a few moments longer.

At noon the stars are old.
Some have died, their lights gone out;
Sidereal convulsions, galactic tremors,
Tell of time and change.
No one noticed when Earth ceased to be,
Disintegrating into cosmic dust,
For long ago its Little Tenant
Had laid himself down in sleep
Deep and never ending.

Dusk and long waves
Spread throughout space and time,
Changing here, arranging there,
A never-ending flow
On and on through cold and darkness
Toward a rebirth and a new dawn
Or to eternal death.

STRIP MINING AND LAND UTILIZATION IN WESTERN PENNSYLVANIA

E. WILLARD MILLER

Dr. Miller (Ph.D., Ohio State, 1942) taught geography and geology at Western Reserve University in the Army Air Corps program in 1943. Later he did map intelligence work in Washington for the Office of Strategic Services. Since 1945 he has been chief of the Division of Geography at the Pennsylvania State College.

STRIP mining, the process of removing an overburden of rock from an underlying mineral resource, is one of the oldest mining methods. Open-pit mining for such minerals as iron ore, limestone, and slate has been practiced for hundreds of years, but the mining of coal by stripping is a relatively modern phenomenon. The development of this type of mining, which requires the movement of tremendous quantities of earth as a result of the relative thinness of coal seams, became important only after the development of the large power shovel. With this advancement coal strip mining is a comparatively simple operation.

Bulldozers first remove the weathered surface materials, and then large power shovels or draglines remove the bedrock. The largest of these draglines in western Pennsylvania has a capacity of 40 cubic yards and can move overburden to a thickness of 70 feet. Strippers indicate they can remove 15 feet of overburden for each foot of coal, the amount varying somewhat with the type of bedrock encountered. After the overburden has been removed, the coal is mined by smaller shovels and loaded into trucks, which normally haul it to the nearest railroad.

The advantages of strip mining over subsurface operations are many. One acre of coal, 3 feet thick, will produce by stripping operations approximately 5,000 tons, whereas in underground mining the average recovery will be about 3,300 tons. Eighty to nearly 100 percent of the coal can be recovered by surface methods, whereas underground mines recover only 40–60 percent of the seam being mined. Strip miners use larger units of machinery than underground miners, so that in 1948 the average surface miner produced nearly 15 tons of coal per day compared to a little over 6 tons for the subsurface worker. Investment in stripping machinery is high, but the salvage value is much greater than that of underground equipment, and in strip mining the interval between initial investment and full production is comparatively short. As a result of minimum danger in open-pit operations, insurance for the surface miner is 2.1 percent per hundred dollars of pay roll; for subsurface workers it is 4.3–4.8 percent. The strip mine operators are unhampered by traditional methods and techniques.

There are also several disadvantages to surface mining. The outcrop of the coal seam suitable for mining is frequently irregular, and if the overburden becomes too thick mining operations must be abandoned. In contrast, coal which is exposed on the surface is weathered and consequently has a low B.T.U. value and usually a high ash content. The greatest problem of strip mining, however, is the restoration of land after the scrappers and power shovels have worked to uncover the coal. Although the spoil banks offer opportunity for reclamation for a variety of uses such as forestry, pasture, nut and fruit crops, wildlife, and recreation, they have commonly remained areas of complete abandonment.

TRENDS OF STRIP MINING IN WESTERN PENNSYLVANIA

Strip mining of bituminous coal became a significant part of the industry about thirty years ago in the Midwest, but coal stripping operations in the Eastern fields were small until the beginning of World War II (Fig. 1). The Pennsylvania bituminous strip mining production averaged less than 750,000 tons annually until 1938. A number of factors retarded the development of surface mining in the Eastern fields. Pennsylvania is one of the oldest centers of coal mining in the United States, and underground mining facilities are highly developed. Also, from 1920 to 1939 coal production of the United States did not exceed that of the World War I period, so that there was small need to develop the near-surface coal seams. During this period the stripped coals, frequently mined by the small producer with little or no equipment to clean and size the coal, were usually

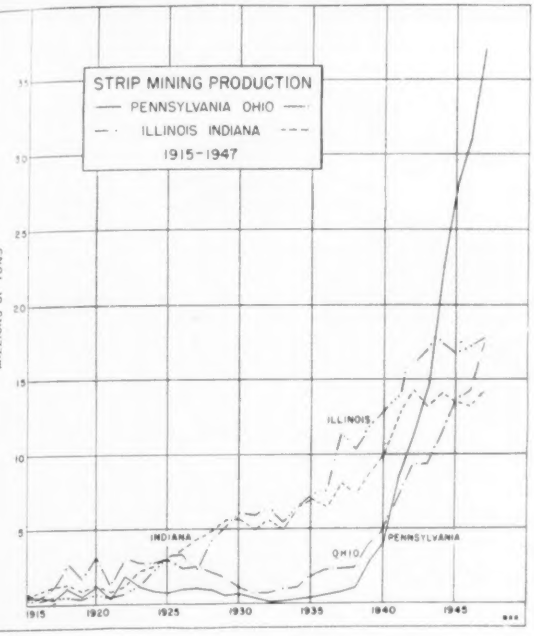


Fig. 1. Strip mine production of bituminous coal in four leading states. Note the significant rise in output in Pennsylvania since 1940.

of low quality and not accepted by the general public.

As a result of the gradual depletion of some of the readily accessible underground coals, the growing demands for fuels in World War II, and the decreased number of underground miners, the Pennsylvania coal producers began to exploit the near-surface coals. Production increased steadily from an output of 2,792,000 tons in 1939 to a peak of 37,075,145 tons in 1947. As a result of the declining domestic and foreign market in 1948, strip mine production decreased to 33,483,000 tons. In 1944 Pennsylvania surpassed Illinois as the principal producer of surface coals and is now far in the lead. At the present time Pennsylvania produces 32 percent of the nation's stripped coal and has 44 percent of the total number of strip pits. The state also has 37 percent of the workers and 40 percent of the power shovels engaged in stripping operations. One out of eight coal miners in Pennsylvania is now working in strip mines.

The percentage of coal mined by stripping in the state has consequently risen remarkably. Until 1938 open-pit output was less than 1 percent of the total. Stripped coal increased to 8 percent of the output in 1942, and only two years later 16 percent was from strip pits. The 1948 stripped coal production was nearly 26 percent of the total bituminous coal output of the state. It has only been through surface mining that Pennsylvania has maintained its high coal position in the nation in recent years.

Strip mining did not develop uniformly in western Pennsylvania (Fig. 2). On a volume basis Washington County leads with a production of 5 million tons annually, followed by Allegheny, Clearfield, Clarion, and Cambria counties, each with between 2 and 4 million tons. Seven counties have over a million tons production annually, and 16 counties have an output varying from 1,000 to 500,000 tons.

The growth and relative importance of strip mining in each county is shown in Figure 3, which compares the percentage of bituminous coal produced by strip mining in 1941 and 1947. Although strip mine production was greatest in both years in Washington and Allegheny counties, the percentage mined by surface operations was small because of large underground output. Strip mining gained its greatest relative importance in the northern counties at an early date and has strengthened its position up to the present. Surface mining, because of its lower operational costs, can mine coals which would not be economically feasible for underground mining. The average thickness of stripped coal decreases northward in Pennsylvania (Fig. 4). The average thickness of surface

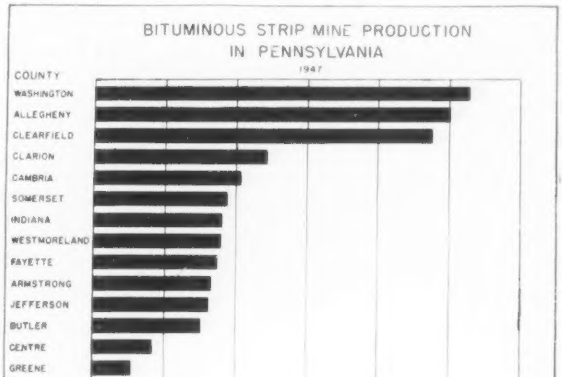


Fig. 2. The bituminous strip mine production by counties in Pennsylvania in 1947.

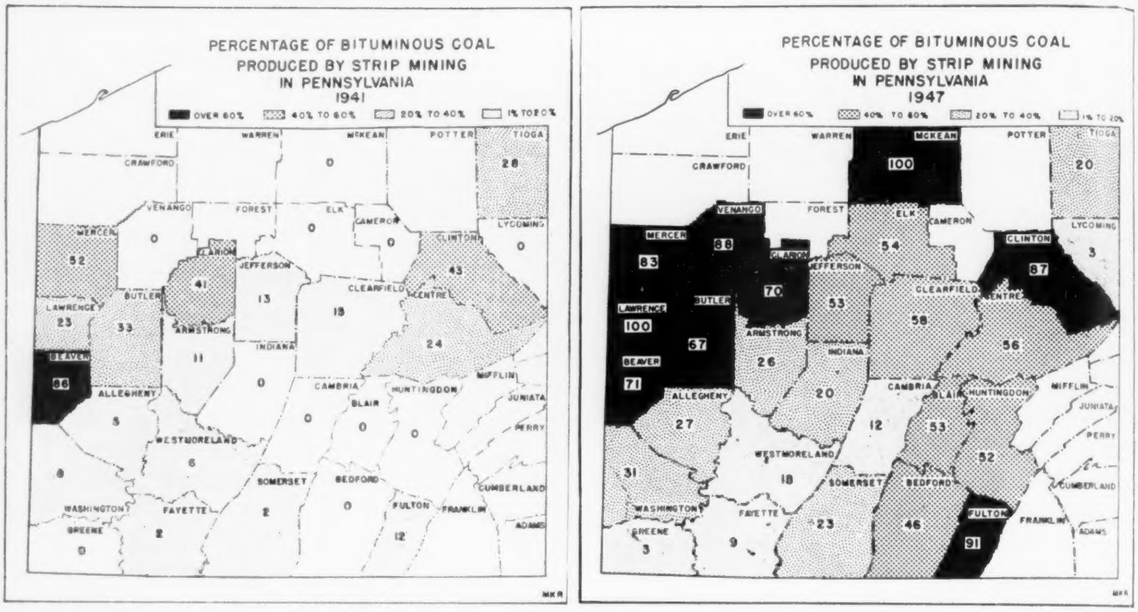


FIG. 3. A comparison of the relative importance of strip mining on a county basis in 1941 and 1947.

coals in the southwestern counties varies from 60 to 73 inches, whereas the average thickness is but 35–50 inches in the northern counties. Coal seams as thin as 12 inches are being stripped in several sections. As a result of the development of efficient stripping technology, coals are being mined which were previously submarginal. Since 1941 underground mining has declined relatively and strip mining has expanded in essentially all coal-producing counties in western Pennsylvania.

PROBLEMS RESULTING FROM STRIP MINING

To the average citizen the most striking feature of strip mining is the destruction of the scenic beauty by the development of unsightly spoil banks (Fig. 5). Because there are usually numerous small operations in an area, possibly affecting not more than 5–8 percent of the land, the scenic beauty of the entire landscape will be marred. It is a common experience to drive along roads for miles in western Pennsylvania and never be out of sight of abandoned spoil banks. Many areas, mined as long as thirty years ago, are today only partially covered with low thorn brush, which is not only unsightly but has no economic value. The continued expansion of the spoil banks affects the tourist trade of the state directly, for this trade is based primarily on maintaining an unimpaired natural environment. In recent years the tourist trade has added more than $500,000,000 to the gross income of the state. If the natural beauty of large sections is marred, one of the largest industries of the state will gradually decline.

Since stripping operators select, whenever possible, the least rugged areas and those which have been cleared of trees, the destruction of productive farmland is a major consideration in the loss of future productivity to both the individual and the

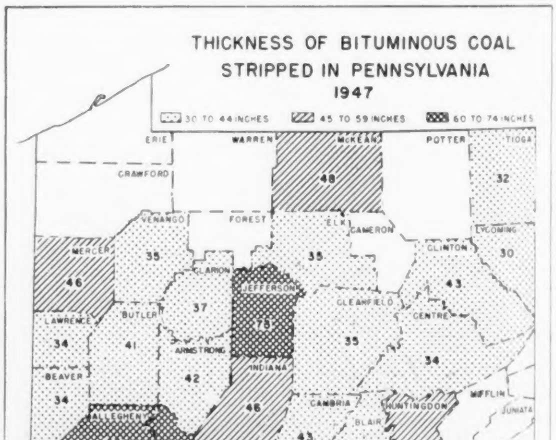


FIG. 4. The average thickness of bituminous coal stripped in each county in western Pennsylvania in 1947.

state (Fig. 6). It is common practice for the coal stripper to justify his operations by the statement that 85 percent of the land mined has been classified as agriculturally submarginal and that consequently he has no responsibility for its reclamation. There is, however, essentially no land in western Pennsylvania that will not produce timber. It is also mistakenly thought that turning the soil over may add to its productivity, and this might be true if stripping were limited to 2 or 3 feet of the surface. With modern stripping extending to depths of 30–70 feet there is little but bedrock on most spoil banks. However, as long as profits obtained per acre by the farmer are 100–300 times the agricultural income of a single year, farmland will continue to be sacrificed with little consideration for its reclamation.

Erosion of the exposed raw earth in spoil banks and, particularly, of leveled areas that are on a slope with no vegetation to hold the ground is another grave problem (Fig. 7). It is common to find gullying 6–12 inches deep on newly leveled areas. Since many of the spoil banks are on the higher slopes, the raw earth has been carried over lower agricultural lands, thus destroying their productivity. Many of the small streams have become highly silt laden, with the consequent killing of fish.

Another problem has resulted when the trench made by the last cut has not been filled. If the ditch between the last spoil bank and the high wall is allowed to remain open it normally fills with water. The water which seeps out of the coal seam usually has a high iron and sulphur content and is consequently acidic. When this water runs into streams, as it often does, it adds to the destruction of fish. The excessive seepage of water out of the horizon lowers the general water table of the mining region, and as a result many shallow springs have dried up in recent years. The high wall, which may be as great as 70 feet, is also a hazard in the area, for there is usually no guardrail to prevent animals or individuals from falling over the cliff. It is particularly dangerous to cattle. Several people have received fractured limbs as a result of falls.

Many of the secondary and some of the primary roads of western Pennsylvania were not constructed to carry heavy truck traffic. The weight of the load carried by coal trucks varies from 3 to more than 20 tons. Because of the extraordinary wear imposed by such loads the surface of many of the roads is broken and pitted with holes. Although many of the coal operators keep road crews and graders continually at work maintaining haulage roads from the mine to the public highways, the state roads have deteriorated in some sections so that they can hardly be used. The Department of Highways is now limiting the load on most roads to less than 10 tons, and state police are rigorously enforcing this regulation.

PATTERN AND EXTENT OF STRIP MINING

What is the pattern of strip mining, and how large an area is mined each year are foremost questions which must be answered before an effective reclamation program can be inaugurated (Fig. 8). As a result of stream erosion in the Appalachian plateau, the surface coals usually outcrop near the top of the slope. The mining operation begins at the outcrop and extends into the hillside until the overburden becomes too thick. Thus, strip mining normally follows a given contour around the slope. It is common for a stripped area to be less than a hundred feet wide and possibly a mile long. A single strip pit will cover from as little as one acre to—rarely—more than 50 acres. In recent years there have been nearly 1,000 power shovels operating between 600 and 700 strip pits. Since the beginning of intensive operations in 1939, and extending through 1948, there have been approximately 38,000 acres strip mined in the bituminous coal fields of Pennsylvania. At the present rate of production and technological advancement, it is estimated that strip mining of coal in Pennsylvania will continue for at least another twenty-five years.

RESTORATION OF STRIPPED LAND

Until 1945 reclamation of strip mined areas in western Pennsylvania was accomplished by individuals, companies, or by local government regulation. The program was entirely unorganized, and the total amount of land restored was very small. For the most part private individuals did little to restore stripped areas, although in isolated instances the better farmers stipulated in their contracts with the miners that the topsoil be removed by bulldozers and then replaced after the mining operation was completed. This method preserves the good agricultural lands, but it lowers the individual's profit and has not developed as a standard reclamation method in strip mining. The common practice was for farmers to plant a row of trees along the edge of the stripped areas which face public highways or the farmhouse in order to hide the devastated land, and the remainder of the land was left for nature to restore.

A few of the larger coal companies, which have long-range mining programs, restored most of the

land they stripped. One company, operating near Burgettstown in Washington County, leveled spoil banks to less than a 20 percent slope. On about 100 acres the topsoil was removed and, after mining, replaced and the area seeded with a mixture of clover, alfalfa, and red top grass. On another 120 acres coniferous trees were planted. In this same section a lake 0.5 mile long by 0.25 mile wide and 25 feet deep at the brest was constructed in 1943 and is now stocked with fish. The tree growth has been good, so that it has become a district recreational center. On another stripped area near Pittsburgh a dairy farm was established on reclaimed land to supply dairy products to

FIG. 5. An abandoned spoil bank in Mercer County, Pennsylvania. This bank is three years old, and no vegetation has yet appeared.

miners in the area; still another company has constructed a private airfield, with runways 1,800 and 2,200 feet long. A number of the companies plan to utilize the timber produced on the stripped areas in their underground mines. Unfortunately, strip mining has been largely developed by small producers, who are primarily interested in securing a maximum profit. It is estimated that not more than 300 acres were restored by larger corporations prior to 1945. These early reclamation projects do prove, however, that a profit can be secured when complete recovery of the land is a part of the program.

Under powers granted by the state, local governments may establish zoning laws to control stripping operations. Penn Township in Allegheny County is the only area that has taken advantage of this means of regulation. In 1940 the township was zoned into residential, business, and industrial districts. Most of the strippable coal is located in restricted residential sections. A zoning Board of Adjustment, appointed by the Township Commissioners, grants a permit to remove coal as a variance from the zoning regulations after application from the owner of the land is approved. The permit is granted to the owner of the land and the coal stripper that he designates. In order to guarantee effective reclamation, the township requires a bond of $1,000–$2,500 for every acre to be stripped. The township solicitor has ruled that in the industrial zone a stripper may mine without a permit, but bond must be posted to assure restoration of the land. Since 1940 all stripped land has been leveled to its original contour and reseeded in grass. Five companies have strip mined coal in Penn Township and have reported a fair profit on their operations, and none have forfeited their bond. Penn Township is the sole example in Pennsylvania where a large area of stripped land has been completely reclaimed.

A unique example of reclamation was developed by the community of Grove City, which in 1932 took 225 acres that had been stripped in 1918 and developed a community park (Fig. 9). Trees were planted and drives were laid out. On four acres picnic sheds, a swimming pool, a bath house, a children's playground, and tennis courts have been constructed. This work was done largely by the

FIG. 6. Spoil banks around a farmhouse in Clarion County. Productive land in foreground.

Civil Works Relief Administration and cost approximately $40,000. It is now the most attractive community park in western Pennsylvania. Other cities could well follow this example, for many of the spoil banks are on the outskirts of towns.

When reclamation of stripped land was left to the discretion of the individual operator or local regulations, the restoration program was highly ineffective. It is estimated that not more than 3–5 percent of the total area stripped by 1945 was restored and is now productive.

As the area of spoil banks increased rapidly during World War II, demands were made by conservationists, certain newspapers, farmers, and a few progressive citizens to develop state control over reclamation of stripped land. This led to the passage of the Bituminous Coal Open Pit Mining Conservation Law in 1945. The law requires that each miner planning bituminous stripping operations must register with the Department of Mines, deposit a filing fee of $100 for each stripping operation, and post a bond of $300 per acre to be stripped, with a minimum bond of $3,000. Liability under the bond is for the duration of open-pit mining at each operation, and for a period of five years thereafter. Within thirty days after starting the removal of overburden the miner must file an operation report giving the location, description of the tract, and the name of the landowner.

The act also requires each strip mine operator to cover the exposed face of the unmined coal within one year after completion of mining, and to level and round off the spoil banks sufficiently to permit the planting of trees, shrubs, or grasses. The slope of the leveled areas is not to exceed 45 degrees. After the leveling is completed, the miner must plant the stripped area to the satisfaction of the Department of Forests and Waters. If the operator fails to comply with the regulations of the law, he forfeits all or part of the posted bond. The

FIG. 7. Erosion of a newly leveled spoil bank when there has been no attempt to plant grass or rye or cover with a layer of mulch until trees hold the ground in place.

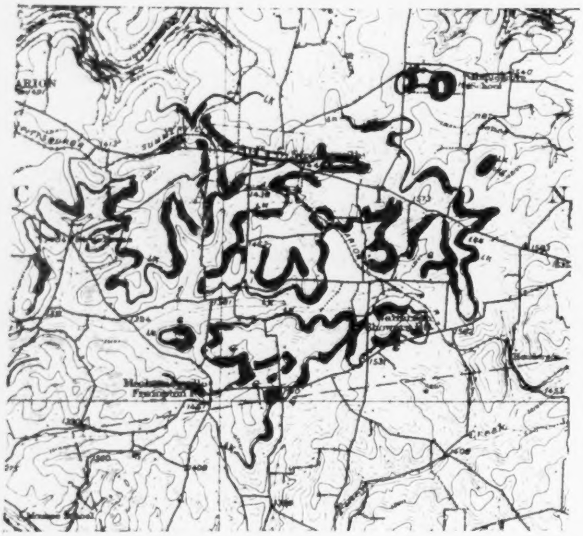


FIG. 8. The pattern of strip mining in a section of the Clarion Quadrangle in Clarion County, Pennsylvania. The blacked-in portions are stripped areas. The map represents an area approximately five miles square.

first bonds will be forfeited in May 1950, which will end the initial five-year period since the passage of the law. It now appears that a large percentage of the bonds issued since 1945 will be forfeited, and then it will be the responsibility of the Department of Forests and Waters to restore the productivity of the land.

The conservation law was strongly attacked by many of the bituminous strip miners. The Central Pennsylvania Strippers Association was organized to protest the passage of the conservation law, and in 1946 contested its constitutionality in the Dauphin County Court. The strip miners based their attack on the leveling of the spoil banks and the payment of a registration fee. The court decision was against the miners, and the validity of the law was upheld.

The reclamation of stripped land presents difficulties not previously encountered in the revegetation of an area. The average coal miner has no real interest in the recovery program, so if it is to be successful a simple, direct technique must be evolved. Numerous questions, such as the best method of leveling the spoil banks, type of trees, shrubs, or grass to be planted, erosional control until a cover crop develops, and length of weathering period in order that the raw earth will support a satisfactory vegetation growth, have to be answered to assure satisfactory reclamation. Since 1945 a number of field research programs have been initiated by the state. Preliminary studies by foresters, geologists, and geographers indicate that stripped areas differ widely in their ability to support vegetation, owing to such factors as variations in the physical and chemical composition of the rock debris, the differences in slope, and the quality and quantity of available water supply.

In the coal regions of western Pennsylvania the greater portion of the overburden of the surface coals consists of shale, a compacted clayey rock which does not become plastic when wet (Fig. 10). It is weak mechanically and slowly weathers into a clay, thus gradually providing soil material. In many districts sandstone layers are encountered. Sandstones are mechanically much stronger than shales and in spoil banks may form a jumble of boulders that resist weathering for very long periods. When limestone or limey shales occur in the overburden, these tend to neutralize the acidic waters and thus aid vegetational growth.

The spoil banks usually contain a number of minor materials that retard plant growth. Pyrite, an iron sulphide, is commonly found near the top of the coal seams and in the "boney" parts of the bed. Consequently, in the stripping operations, when the earth is overturned the pyrite is normally deposited near the surface of the spoil banks. When exposed to air and moisture these particles decompose to iron sulphates and on further oxidation and hydration form rusty iron oxides and sulphuric acid. The acid, though hastening the weathering process, hinders plant growth. Soluble alumina formed by the reaction of acid on shales likewise is harmful to plants. Where pyrite is abundant a much longer period of weathering is needed before planting is desirable.

The quantity, quality, and distribution of the spoil bank waters are also important factors in revegetation. The irregular surface of the leveled areas may have numerous clay depressions where water collects for long periods after rains. In these places trees may be completely covered for several weeks and are usually drowned. In dry periods these clay depressions usually become hard pans; in other areas the material may be exceptionally porous and the surface will become dessicated quickly. The acidity of the water will depend on the rapidity of weathering and will usually vary from a *p*H three to six.

The slopes of the raw spoil banks and leveled areas vary considerably. It is common to have slopes as great as 40 percent; if the slope exceeds 50 percent the survival of trees is low. The Conservation Law requires no preparation of the spoil bank beyond leveling, so that fertilizers are very seldom applied before planting.

Under such physical conditions some type of coniferous trees has usually been found to be most

practical (Fig. 11). The red, Banks', shortleaf, and pitch pine, Norway and white spruce, and hemlock are commonly used. Although the growth of coniferous seedlings is generally satisfactory, they do not stabilize spoil bank surfaces quickly, and thus the natural regeneration of hardwood species is retarded. The shortleaf and pitch pines are particularly suitable for sandstone and acid shales. If the soil is highly acidic, Japanese larch is one of the better trees to plant. In a number of places where the earth is moderately acidic, red oak and black locust have been successfully grown; black locust is particularly satisfactory if a quick vegetational covering is desired. It also develops a surface litter of 2–3 inches in six to nine years, stabilizing the spoil bank. Besides stabilizing the earth and modifying the highly fluctuating soil moisture and temperature of the bare surface, the litter affects the beginning of soil formation. The black locust also has an abundance of nitrogen-fixing nodules on its network of fibrous roots, which stimulate plant growth in the soil. Normally, after about ten years, a luxuriant covering of herbs, shrubs, and hardwood reproduction develops as an undergrowth. The planting of this tree should be given greater consideration.

In western Pennsylvania most plantings have been of a single species. In general, mixed plantings of several species would be more desirable because of the greater protection from insect and disease attacks, and the benefits of site improvement. Furthermore, if the season of planting is less favorable to one species than to another, mixed stands offer less likelihood of complete failure. The trees for reclamation projects may be obtained from a state or private nursery, and both seedlings and transplant stock are used. If seedlings are used, the root system and the top should be well developed in order to survive. The transplanted stock is found to be superior, but it is more expensive—and reclamation costs are usually kept at a minimum. Early spring or late fall is the best time to plant trees. After planting, exposure to strong, cold winds and complete covering of snow for long periods reduces the survival rate.

There has been considerable disagreement among conservationists as to whether spoil banks should be leveled before restoration or reclaimed in their original state. A common Midwestern viewpoint has been that leveling the spoil banks with a bulldozer compacts the earth to the extent that it greatly hinders plant growth. It has also been argued that leveling the ridges prevents the miner from making a profit. The evidence to support either of these contentions is largely lacking in western Pennsylvania. If the spoil banks are not leveled it is extremely difficult to traverse them because of the steep slopes. The original spoil banks are also likely to be more porous and consequently so dry that plant growth is almost impossible to maintain. Average profits from strip mining operations have been exceedingly high, so

FIG. 9. The community park at Grove City, Pennsylvania. A reclaimed strip-mined area.

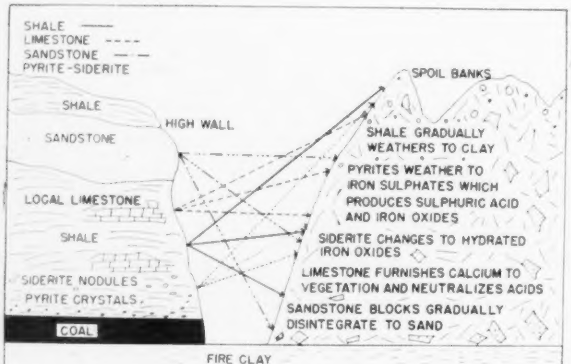


FIG. 10. A diagrammatic sketch of bedrock in the coal region and the location of debris in the spoil banks.

that restoration practices should become a part of normal mining costs.

What is the best method of leveling the spoil banks has been another significant problem. At the present time, since most operations have taken place on a slope, the miner pushes the earth downhill and rarely destroys the high wall. This type of leveling could be greatly improved. The high wall should be destroyed in order to rid the region of a hazard. When the banks are leveled outward from the last furrow, a considerable amount of land which was not affected directly by the mining operation is covered by raw earth. A more desirable method of leveling would be to push the earth into the last furrow made by the mining operation. By this procedure, the trench is filled and the raw earth is limited to the original area of mining.

Present strip mining machinery has been developed specifically for mining coal, with little thought of reclamation. With traditional methods, most of the topsoil is deposited on the bottom and the rocky material on the top of the spoil bank. Two types of excavators have now been developed which would save the topsoil and partially level the spoil banks during the mining operation. The first is a dragline with a 215-foot beam which precedes the stripping shovels. This dragline removes the topsoil and deposits it between the two preceding spoil banks. The ridges left by the stripping shovels are covered, and the intervening valleys partially filled with topsoil. In Illinois a new type of wheel digger and conveyor is now being tested in the field. A large revolving wheel about 30 feet in diameter, with buckets attached to its outer edge, is pressed against the perpendicular face of the high wall of topsoil to be removed. The buckets dump the soil on a conveyor belt, which carries and deposits it over the two preceding spoil banks and their intervening valleys. With either of these excavators the revegetation of the banks is greatly simplified. Neither of these machines has so far been used in western Pennsylvania.

As the reclamation program has developed, a number of practical weaknesses have appeared in

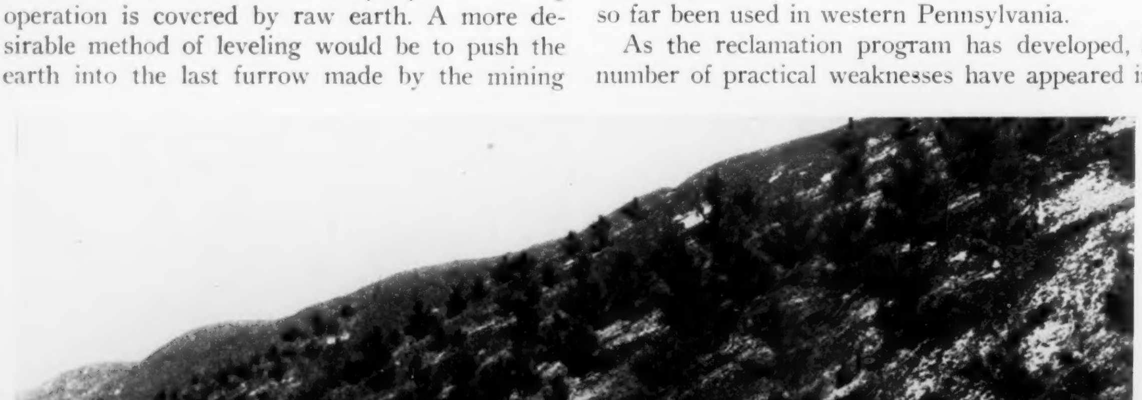


FIG. 11. A spoil bank partially reclaimed in red pine. Growth has been about 8–10 inches a year. Slope of the bank averages 40 percent and the *p*H rating of the shaly soil is 4–5.

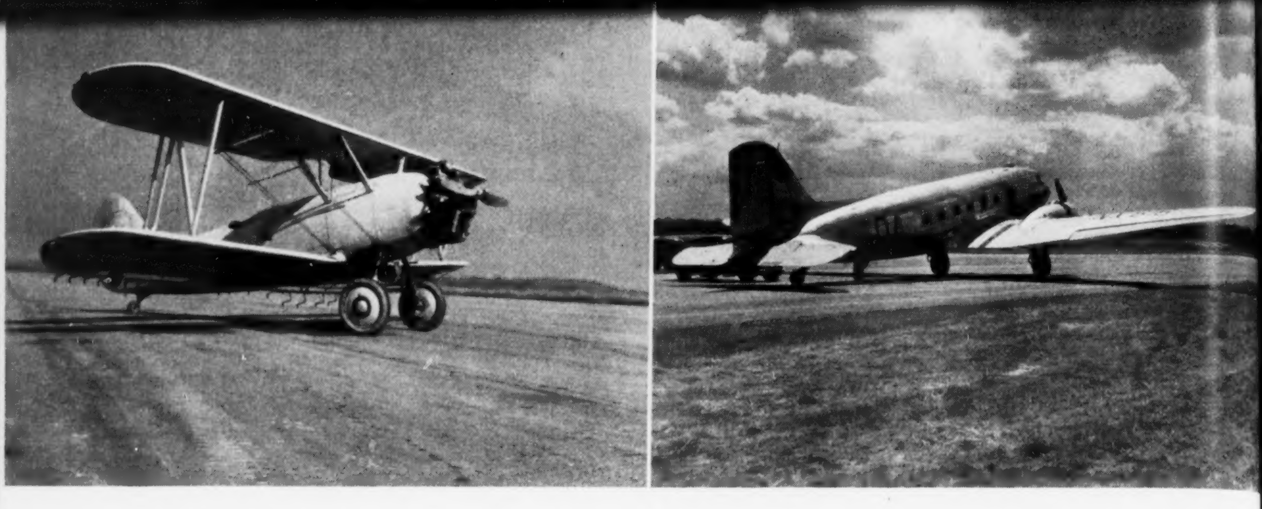
the Conservation Law, which reduces the possibility of complete restoration in a minimum length of time. The present law requires that complete reclamation be finished within a year of the end of mining. This regulation gives little time for any weathering of the spoil bank area to reduce the acidic condition or develop a better soil. This appears to be the single greatest defect of the present law. From field observation during the past five years it would seem more desirable to level the spoil banks immediately upon completion of the mining operation and then allow a period of time to elapse before planting trees. Stripped areas which have been planted three or more years after the mining operation normally have an 80–95 percent growth of trees, whereas trees planted immediately on the exposed raw earth have a 10–90 percent growth, with an average growth of about 40–60 percent. Erosion of the earth in the stripped areas should be controlled from the time leveling is finished until a vegetation covering holds the loose soil in place. This can be done fairly effectively and inexpensively by scattering a layer of mulch such as straw or leaves on the earth; where possible, the planting of rye, grass, or a shrub covering will advance the restoration. In order to implement these proposals the present law needs amending. The strip miner, who has available heavy machinery such as the bulldozer, should level the spoil bank immediately on completion of the mining operation, and then pay the Department of Forests and Waters a sum sufficient to cover the stripped area with a mulch and later to plant it in trees. Most strip miners favor this policy, for they are fundamentally interested in mining coal and not in reclamation work. The owner of the land would also gain, for there would be few failures. At the present time, if the land is planted by the miner and the work approved by the state, and the trees die, the owner must replant at his own expense. There is little indication that many present owners will replant the land.

CAVITATION

At Northwestern University's Technological Institute civil engineers are studying cavitation in flowing water. Turbine blades and walls of conduits in dams have been torn away by the continued occurrence of cavitation, and ship propellers have had to be repaired or replaced as a result of the violence of exploding bubbles of water. Wallis S. Hamilton, associate professor of civil engineering, and two of his graduate assistants, will determine, by means of newly designed research apparatus, which materials can withstand cavitation.

"By changing the curvature of the walls, using materials found to be the most impermeable, and directing bubbles away from the walls before they collapse," Professor Hamilton said, "we hope to design machinery which will operate without damage, even though cavitation occurs."

Researchers at California Institute of Technology are using high-pressure water tunnels and high-speed motion picture cameras to determine how damage by cavitation occurs.



SOME CONSIDERATIONS OF THE BIOLOGICAL EFFECTS OF DDT

C. H. HOFFMANN and J. P. LINDUSKA

Dr. Hoffmann (Ph.D., Minnesota, 1935) has been with the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture since 1935. He is attached to the Division of Forest Insect Investigations and is in charge of a project to study the effects of DDT on gross insect populations important as natural control agents and as food for fish and wildlife. Dr. Linduska is in charge of investigations on the effects of insecticides and herbicides on wildlife and fish populations for the U. S. Fish and Wildlife Service. He has done research in wildlife management and insect control since 1935 and made contributions to the development of insect repellents for the armed services during World War II.

THE much-publicized wartime accomplishments with DDT caused many people to be apprehensive of the insecticide's subsequent application to civilian problems. There were good reasons for concern. A material one ounce of which was reported to be adequate to eliminate mosquito larvae from an acre of water certainly appeared to have potentialities for harm. Furthermore, this high toxicity made it especially adaptable for distribution by plane, thereby reducing operational costs; moreover, the toxicant itself was moderately priced. The whole picture was one of bigger and better control projects involving more and more acreage.

The early estimates of greatly expanded insect-control activities following the development of DDT were not exaggerated. Many crop pests are now being controlled more effectively and economically than ever before. For the first time, outbreaks of several species, particularly pests on forest crops, have been subdued by direct control measures. The well-deserved reputation of DDT as an agent for mosquito control has greatly increased the marsh acreage effectively covered in mosquito-abatement districts.

At left above: N3N trainer plane equipped with centrifugal pump and spray boom (*beneath lower wing*). *Right:* C-47, equipped for spraying. Successfully used to distribute DDT for control of the tussock moth infesting thousands of acres of forest land in the West (1947) and for gypsy moth control over large, inaccessible forest areas in the East (1948).

Although the immediate advantages of DDT as a control agent have been demonstrated on a wide scale, the possible hazards, particularly those resulting from repeated and long-time use of the insecticide, are not so well known. Many investigations of the general biological effects have been made, however. Since 1945 the Fish and Wildlife Service and the Bureau of Entomology and Plant Quarantine have cooperated in studying some of the biological effects of forest-insect control. More than twenty experimental areas, ranging in size from 100 to 300 acres and including various forest types and forest pests, have been studied in detail after application of 1–7 pounds of DDT per acre. Three major insect-control areas, ranging from 100 to nearly 650 square miles, also have been studied to determine any harmful effects. The U. S. Public Health Service, through its laboratory at Savannah, Georgia, has devoted much time and effort to evaluating the biological effects of anoph-

eline larvicides. Investigators of the Tennessee Valley Authority also have reported results from detailed inquiries on the general effects of mosquito control. A number of other agencies and many individuals have either participated in these studies or conducted independent investigations.

For the control of many insect pests of the forest, DDT dispersed as spray from airplanes has proved to be highly effective. In such operations various aircraft and distributing devices have been used. The most common spray apparatus is a simple boom with nozzles attached along the underside of the wings. The open-cockpit biplanes (N3N, Waco, or Stearman) ordinarily are flown 50–100 feet above the forest canopy, and at this altitude the spray swath may range from 90 to 110 feet. Larger airplanes, such as the C-47, are flown at higher altitudes; approximate width of the swath is 500 feet. The C-47, flying at 160 miles per hour, will treat 900 or more acres of forest in about eight minutes. In many experimental areas, filter papers were put out in open sites to sample the deposit left by the DDT spray.

For biological evaluations, study plots were established in sprayed areas and in comparable untreated areas. General observations and population counts were taken in both sprayed and unsprayed areas before, and at various intervals after, the spraying. Insect populations in different habitats were sampled by many collecting and trapping methods. Arboreal species were captured on sheets under the trees by tree jarring, and also in cloth-bottom trays placed on the ground to catch affected insects as they fell. Flying insects were captured in light traps, fly traps, box-area traps, and on boards covered with an adhesive. Certain ground species were taken in traps baited with fish or molasses, and in modified Berlese funnels. Sweep-net collections and general observations furnished data on other species. Insect populations in streams were measured by means of a square-foot sampler. Thousands of terrestrial and aquatic insect specimens, involving 800 species or groups, were collected and identified during the four years of study.

Information on reptiles and amphibians was obtained by making general observations in the field, by marking and releasing, and by confining species in open outdoor cages. Most of the studies on birds were made at the peak of the nesting season, when individuals were confined to established territories. Singing males were tallied, and by means of systematic trips the actual population of nesting pairs could be determined for measured plots. Small mammals were studied by live-trapping and marking, and larger forms by systematic observations. Wherever practical seine hauls were made, to estimate fish populations. Weirs, which were sometimes installed in sections of the streams to stop any affected fish, also were helpful in studying cumulative effects of the poison. In addition, live boxes containing known numbers of different species of fish were placed in some waters.

Generally speaking, aquatic species are affected more by DDT sprayings than are terrestrial animals. This difference may be due partly to inherent differences in susceptibility. It is more likely, however, that the intimate and continuous contact with the insecticide in aquatic environments produces greater effects. In several of the study areas both habitats were sprayed, but because of marked differences in effect on faunal groups in the two types it will be profitable to consider the results separately.

EFFECTS ON TERRESTRIAL LIFE

Insects. Wide variations were observed in the extent to which species of terrestrial insects were killed with DDT. Aside from some inherent differences in susceptibility to the poison, these variations may be attributed to differences in opportunity of coming in contact with the poison. Generally speaking, the species exposed on vegetation were more affected than were those protected under bark, in burrows, in leaf mold, and in soil. Most of those coming in contact with DDT when they were in susceptible developmental stages were severely affected. Caterpillars and flying adults of several orders were killed in large numbers, but species in a protected stage at the time of spray application and during the period when the residue was toxic were unaffected. Hairy insects, such as moths and bees, appeared to be resistant.

In most forest sprayings insects of many families and orders were greatly reduced in numbers even at the relatively low dosage of 1 pound of DDT per acre. The residual effect lasted for about a week. The effects of widespread spraying on biological control agents are of great importance. In the spraying of 14,000 acres for the control of the tussock moth in Oregon, some interesting observations on a larvaevorid parasite have been recorded. Although parasites in flight at the time of the spraying were killed, those that emerged later, plus those that survived in areas missed by the spray, were sufficient to parasitize tussock moth larvae not destroyed by disease or the spraying.

The results of a study made in Massachusetts indicated that a single spraying at about 1.5 pounds of DDT per acre was sufficient to eradicate

small gypsy moth larvae without causing any significant permanent change in the general insect fauna. Caterpillar control enabled the sprayed plot to remain in a healthy condition, with an abundance of vegetation and with normal shade and moisture. In contrast, an adjacent woodland, which was heavily defoliated by the gypsy moth, suffered from drought that followed the loss of shade formerly provided by a dense canopy. Post treatment samples showed more than three times as many insects in the sprayed plot as in the two check plots. Although the DDT spraying caused considerable damage to other insects in the treated area, the mortality was far less in the aggregate than that due to the conditions resulting from a heavy defoliation by the gypsy moth.

The effect of DDT applied at the rate of 2 pounds per acre was not prolonged, and most of the species were present in considerable numbers two or three weeks later. Spraying areas of 100 acres or less that might be repopulated by immigration from unsprayed habitats resulted in the following situation: Tree-inhabiting caterpillars were decimated; Hymenoptera were reduced immediately after the spraying, but the population equaled that of the check area one month later; some groups of flies showed no change, whereas others showed an over-all reduction of about 85 percent for two months afterward; many of the leaf-feeding beetles also were reduced greatly in numbers; aphids appeared to increase, although many of their parasites and predators seemed to be unaffected; most ground forms were unaffected by the spray, but a few having an emergence peak at the time of spraying were moderately reduced; only a few spiders were adversely affected.

In experimental forest sprayings with DDT at the rate of 5 or more pounds per acre, 90 percent of the terrestrial insects were destroyed within a few days. All the tree-inhabiting caterpillars were eliminated, but those infesting low vegetation, although reduced initially, gradually reached pretreatment numbers. The hymenopterous parasites of caterpillars were almost eliminated by the spray but gradually came back, until their numbers were perhaps one fourth of normal at the end of three months. Apparently, larger moths were unaffected, whereas the smaller ones were moderately reduced in number. Some flies were almost eliminated shortly after the spraying and showed little recovery that year. Certain leaf-feeding insects were greatly reduced by the spray. Psyllids feeding on the undersides of leaves, scale insects under their protective coverings, and Collembola dwelling beneath bark were unaffected. Many ground-inhabiting insects, including beneficial scavengers and predators, were not seriously affected. Some flies and their various hymenopterous parasites continued to breed in the humus. Ants were affected by the spray, but their numbers were diminished for about a week only. Many arthropods of the soil were not disturbed by the single heavy application. Spiders were variously affected, species living in exposed webs being killed in larger numbers than those in more protected places.

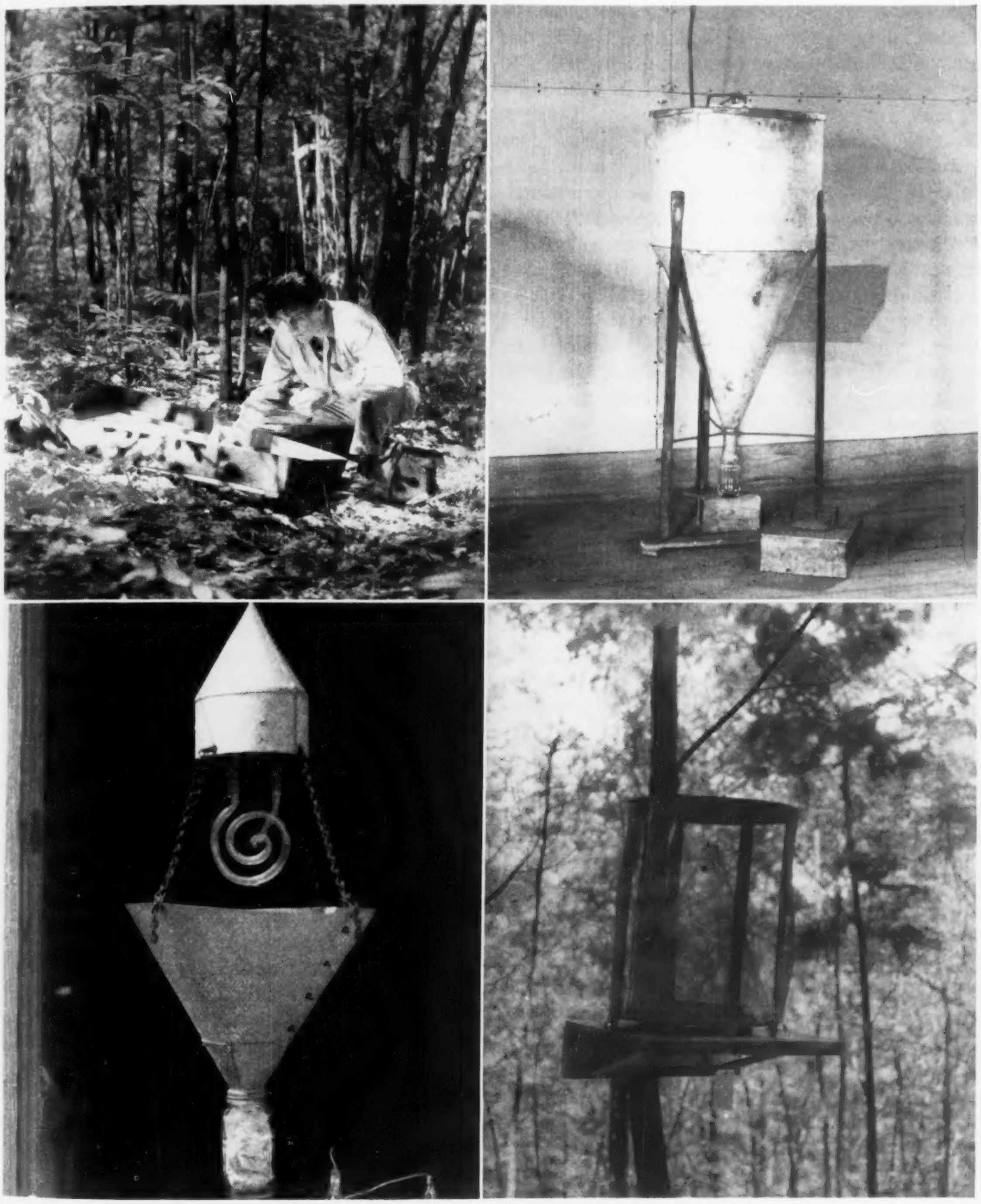
Two outstanding irruptions in insect populations followed a 5-pound per acre application. In one, pretreatment sampling indicated a normal aphid population and what appeared to be a sufficient number of insect parasites and predators to maintain a balance in numbers. Aphids in exposed locations were killed, but others on the undersides of leaves increased in number and later settled on uncontaminated new growth. It is possible that their enemies were affected more seriously by the spray. About six weeks after the spraying, an outbreak of many species of aphids developed on the principal forest trees of the area. Aphid predators gradually responded to the abundance of their prey and became more numerous. These natural control agents could not keep up with the aphid population, however. The most important check on the outbreak was an exceedingly heavy rain, which probably destroyed two thirds of the population. Later, natural enemies caught up with the aphid population, which has remained at the pretreatment level for three years.

The other irruption concerned a mite that was prevalent on oak leaves shortly after the spraying. Approximately one year later there was an outbreak, and noticeable injury was caused by mites feeding on red maple foliage. Similar damage was not evident in near-by areas. A few months later the mites disappeared, and no specimens have been collected in the area for two years.

Studies indicate that a single aerial application of DDT to the forest at the rate of 1 pound per acre, which is sufficient to control many forest pests, does not seriously affect the general terrestrial arthropod fauna. Dosages of 5 pounds or more per acre threaten extermination of many insect species, but do not cause general catastrophic losses.

Reptiles. Scant data are available on the effects of DDT on land reptiles. The few snakes found dead after DDT applications have been associated with dosages of 4 or more pounds per acre. Small numbers of live snakes were seen in the same areas after the spraying. In Texas an experimental attempt to control ticks with 44 pounds of 10 percent

DDT dust per acre was suspected of having caused a heavy mortality of the insectivorous rough green snake. The tendency of most snakes to conceal themselves, preferably in heavy ground cover,



Cloth-bottom tray placed beneath tree canopy to collect DDT-killed insects, and, on right, modified Berlese funnel used to determine invertebrate populations in litter and humus. Heat from light bulb in funnel forces these organisms (7–13,000 per square foot) down through the soil into the alcohol-filled jar below. Shown below is a light trap with coiled argon-mercury discharge tube, whose blue light effectively trapped large numbers of insects, particularly moths. Insects were killed by fumes from pad in bottom of jar saturated with carbon tetrachloride. Stale beer used as bait in fly trap at the right caught up to 8,000 flies per day.

makes it difficult to evaluate populations by direct observation.

Birds. Because most wild vertebrates resist restraint, critical toxicity studies on captive animals are difficult to carry out. Sufficient work along this line has been done, however, with a few species to demonstrate some of the variables in connection with DDT poisoning. At the Patuxent Research Refuge acute and chronic toxicity tests were conducted on four species of birds and three of mammals. In addition to differences in species susceptibility, wide differences in individual effect were apparent. These presumably were due to irregular absorption. Type of formulation had a marked influence on the toxic effect of DDT. With bobwhite quail, for instance, the acute toxic level by oral administration was 60–85 mg/kg of body weight for vegetable oil solutions. When the DDT was administered in crystalline form, the acute dosage was three to four times as great, or about 300 mg/kg.

Combined field-laboratory tests indicated that the method of poisoning in songbirds involves ingestion of the material. Nests, eggs, and newly hatched young of songbirds were sprayed heavily with DDT-oil solutions without effect, whereas nestling birds were killed when fed DDT-contaminated insects. Condition of birds was found to be important in regulating toxic effects. The mortality was increased when a subsequent period of partial starvation was imposed on young individuals.

Laboratory investigations with vertebrates have been of value in indicating some of the factors that may modify the direct toxic effects of DDT, but the application of such findings to field conditions has definite limitations. Although the complex interrelationships of faunal groups are at best poorly understood, numerous investigations have shown that the prosperity of one group may be directly influenced by the status of others. For this reason special emphasis has been given to evaluations under field conditions.

In a number of experimental tests in forest areas, birds were unaffected by a single application of DDT at the rate of 1 pound per acre. Although the general insect population was sharply reduced in nearly all cases, recovery of numbers was rapid, and there was no evidence that the temporary reduction was of any real consequence to birds. Development and survival of nestling young appeared to be normal at this dosage.

Observations on birds in connection with large-scale operations were consistent with the findings on experimental plots. In 1945 the Ontario Department of Lands and Forests, Canada, treated more than 60,000 acres at the rate of 1 pound of DDT per acre for control of the spruce budworm. Intensive studies of birds were conducted on three plots in the sprayed area and on one outside the treated area. Four birds were found showing symptoms of DDT poisoning, two of which subsequently died. Normal development of young was observed in several nests, and no measurable change in populations of adult birds was noted.

In May and June 1947 about 400,000 acres of forest land in northern Idaho were treated for control of the Douglas-fir tussock moth. DDT in oil was applied by planes at a dosage of 1 pound of the toxicant per acre. Detailed studies indicated that the spraying had no apparent effect on a high bird population, which included 44 species. Counts taken after the spraying showed a decline in numbers of 9.5 percent, compared with 10.6 percent in a check area. The slight decline in both areas was believed due to some individuals having completed nesting. Bird censuses accounted for practically all the original individuals throughout the study, and numerous nests and family groups appeared unaffected.

Although dosages of 1 pound per acre or less have not been found to be lethal to birds, some evidences of modified behavior have been observed. On several occasions swallows, flycatchers, and other birds of similar feeding habits have temporarily abandoned sprayed areas. Marsh and aquatic areas sprayed for mosquito control were principally involved.

Studies on birds in areas where four consecutive yearly airplane applications of 2 pounds of DDT per acre were made at the peak of the nesting season have so far shown no deleterious effects. There have been few observations to indicate the effects of aerial applications with intermediate dosages of 2–4 pounds of DDT per acre. With 5-pound per acre aerial applications, however, marked kills have resulted. On one 600-acre tract, sprayed experimentally at this rate for control of gypsy moth larvae, a population in excess of three birds per acre declined in two weeks' time to about one sixth of the original population. One year later the numbers were about 85 percent of the prespray total.

In a second test a 5-pound per acre application to a scrub and sapling growth reduced the number of birds by more than one half. Of the five commonest species in the area, three—the Maryland yellowthroat, the prairie warbler, and the house wren—were reduced by 80 percent. Species with ground-feeding habits appeared to be least affected

by the aerial application. Elsewhere, in connection with attempted tick control, 4 pounds of DDT per acre distributed with ground equipment caused a heavy mortality among ground-feeding species and had a lesser effect on canopy inhabitants.

Additional studies on the effects of high dosages of DDT on birds were made late in summer when birds had completed nesting. These observations were obtained in experimental attempts to control the mountain pine beetle in the Teton National Forest and the Black Hills beetle in the Black Hills National Forest, both in Wyoming. DDT in amounts of 5–10 pounds per acre was applied to irregularly shaped plots, mostly less than 100 acres in size. Detailed censuses of birds were not practicable at this time of the year because of widespread movement. Systematic search over the areas revealed some mortality, but population indices showed reductions hardly commensurate with the high dosages used.

Studies on post-breeding bird populations in Georgia pecan groves revealed similar results. In this area DDT was used for pecan weevil control in dosages as high as 5.5 pounds per acre. No adverse effects on birds were observed.

The nominal effect on birds of heavy dosages of DDT applied under the conditions outlined above is in marked contrast to the situation found for several other areas. Low kills resulting from heavy dosages of DDT appear to be explained by the following conditions: In each case the spray was applied after birds had completed nesting. Relieved of the burdens of nesting duties, and with territorial behavior no longer manifested, the birds were free to range over much larger areas than usual. In addition, all the areas under treatment were small, and the birds with their enlarged daily range probably were flying beyond the limits of the sprayed areas. There is little doubt but that these two factors operated mutually to minimize the effects of otherwise critical dosages.

Mammals. The difficulties of exact census work on mammals have limited the accomplishments in field studies on the group. The larger, wide-ranging species, in particular, have posed real problems in attempts to procure information on possible effects of insect-control operations. However, at least twenty species of mammals, including such common forms as the cottontail rabbit, raccoon, opossum, skunk, deer, woodchuck, and squirrels of several kinds, were under observation in one or another of the studies. Dosage rates under which observations on mammals were made ranged from a fraction of a pound to 7.5 pounds of DDT per acre. In several of the investigations, intensive live-trapping and marking of small mammals were employed in order that population changes might be measured and any abnormal movements of individuals in and out of plots detected. In one study the effects of repeated applications, such as may be practiced in malaria control, were observed. None of these field investigations revealed any measurable effect on the mammal population, although at the higher amounts of 5 and 7.5 pounds of DDT per acre, one shrew and several chipmunks were seen in a condition highly suggestive of DDT poisoning. It is likely that with aerial applications the critical dosage for many mammals is near the 5-pound per acre level. Cottontail rabbits in captivity have been killed by ground applications of 5 pounds per acre of DDT in oil. Because much of the spray is lost when applied aerially, the ground application of the same amount represents a conspicuously more critical treatment.

As with birds, the possible hazards to mammals need not involve only a direct toxic action. In one study, after a comparatively light application of DDT for mosquito control, racoons were secondarily affected by an almost complete kill of crayfish that had been a staple item in their diet. After gorging on the dead crayfish for a few days, they were forced by a depleted food supply to leave the creek bottom and seek other fare in the uplands.

EFFECTS ON AQUATIC LIFE

The high susceptibility of fish and other aquatic forms to DDT has prompted a number of careful studies. In general, investigations have been made along two lines: measuring the hazards of the purposeful application of small amounts of DDT to aquatic areas for mosquito control, and research on the danger of unintentional and unavoidable contamination of productive waters by heavier dosages in connection with forest-insect control and other operations.

The U. S. Public Health Service at Savannah, Georgia, and the Tennessee Valley Authority at Wilson Dam, Alabama, have given particular attention to the biological effects of larvicidal treatments for malaria control. The results have been reassuring in a number of respects. A dosage of 0.1 pound per acre applied by airplane was not found to be unduly harmful to either fish populations or their food supply. Seventeen such treatments at about weekly intervals were applied without causing measurable effects on fish. Moreover, there was no evidence that intricate food-chain relationships of aquatic life were disrupted critically. Since present trends in anopheline control emphasize dosages below 0.1 pound per acre, it

is reasonable to suppose that this important use of DDT will not conflict seriously with recreational and commercial interests.

The control of pest mosquitoes requires larger amounts of DDT, and it is likely that in some of this work such dosages will approach marginal levels of safety for beneficial life. At the commonly used rate of 0.2 pound per acre, however, no disturbing developments were noted. In cooperative studies with the Army at Edgewood Arsenal, Maryland, 0.2 and 0.26 pound per acre, applied one month apart, produced slight effects on fish. Other experimental sprayings of 0.5 pound of DDT per acre caused a moderate to heavy kill of fish and edible crabs.

In the control of forest insects, aquatic situations in project areas will require careful consideration. Extensive experimentation has been done on this phase of possible injury, and present information indicates that a 1-pound dosage represents the approximate limit under which forest-insect control work can be done without appreciable losses in aquatic environments.

Reptiles and amphibians. In 1948 two Pennsylvania watersheds comprising 52,000 acres were sprayed at the 1-pound dosage for the control of the gypsy moth. Small numbers of dead water snakes were found in some of the lakes and streams, and it is believed that these animals are susceptible to DDT poisoning. Few tadpoles, frogs, and salamanders were killed compared with the total populations.

No adverse effects were observed on several species of turtles, bullfrogs, or water snakes when a stream in West Virginia was treated with a suspension at the same dosage.

In a tick-control project at Bull's Island, South Carolina, amphibians were commonly killed with applications of 2 and 3 pounds of DDT per acre. Reptiles were affected only moderately. In a Maryland woodland, open-topped cages stocked with adult green frogs, pickerel frogs, and bullfrogs, adult toads, and frog and toad tadpoles were observed for a few days before and for nine days after the area was sprayed at a 2-pound rate. The heavy canopy of the mature forest intercepted much of the DDT spray, and probably accounted for none of the animals being affected.

Fish and fish-food organisms. In dirt-bottom ponds treated with 1–5 pounds of DDT per acre, practically all the surface insects and those breathing at the surface were eliminated; however, the auxiliary solvent and carrier in this formulation had a like effect on surface forms. Most of the free-swimming and crawling insects were greatly reduced in numbers, and some were exterminated. About two months after treatment all the ponds had recovered markedly, although the species and age groups present were much different from those found before the spraying. Insects living on the bottom of ponds were not affected appreciably by any of the dosages. In one of the shallow ponds treated at the heaviest dosage, several frogs and large frog tadpoles and a young water snake were killed. Some tadpoles and frogs remained alive in all the treated ponds, however.

Aquarium tests with fish showed that numerous factors modify the toxicity of DDT to this group. Marked differences in species susceptibility were observed, and age groups were also affected differently, young animals showing the least resistance. Well-fed fish were less inclined to poisoning by the material than were those from which food was partially or wholly withheld. As with warm-blooded vertebrates, DDT was appreciably more toxic to fish when it was dissolved in oil than when administered in fat-free carbohydrates or proteins. At given dosages of DDT the type of formulation caused wide variations in effects, emulsions, oil solutions, and suspensions representing the order of decreasing effectiveness. Various conditions of the aquatic medium modified results, and warm temperatures, reduced oxygen tension, and soft water all enhanced the activity. Clarity of the water appeared to be of considerable importance both in field and laboratory tests. With applications of 0.25 pound of DDT per acre, 84–100 percent of the rainbow, brook, and brown trout were killed in dirt-free aquaria. The same dosage applied to identical aquaria containing a layer of mud caused mortalities of 0–39 percent in the same species.

In general, erratic results were obtained when insects sprayed with a suspension or an oil solution at 1 pound of DDT per acre were fed to several species of fresh-water fish. Some were killed after devouring relatively few sprayed insects; others gorged themselves without adverse effect; a few exhibited DDT tremors but recovered later. Fish that were fed insects sprayed with an oil solution of DDT usually were more easily killed than those fed suspension-sprayed insects. Well-fed fish survived in large numbers even though they were fasted after a 3-day feeding on DDT-sprayed insects.

Many experiments with DDT formulations were performed in dirt-bottom ponds and concrete raceways and daphnia ponds to test the toxicity of DDT to different species and sizes of fish. Bluegill sunfish and largemouth and smallmouth black

bass 1 inch in length were killed by suspensions and oil formulations in applications ranging from 0.25 to 1 pound of DDT per acre. Fingerling fish 2 inches or more in length withstood the higher rates of application better. In some instances large fingerling or adult fish survived as much as 1 pound of DDT per acre formulations. Fingerling bluegills, smallmouth black bass, and black crappies were more sensitive to DDT than were largemouth black bass, golden shiners, and trout. In raceways with a continuous flow, brook and rainbow trout, smallmouth black bass, and golden shiners were relatively unaffected by a 1-pound dosage of DDT in suspension. In general, fish mortality from DDT suspensions occurred later and to a lesser extent than from oil sprays.

As would be expected where important variables such as closeness of canopy, size, and volume of stream exist, a wide range of results has been evident. In most cases, however, 1-pound aerial applications deposited about one third that dosage at the water surface. This was sufficient to cause a heavy loss of invertebrates. Some mortality of fish occurred in each case, but not enough to be significant in terms of the total population. Young individuals showed a higher susceptibility than older fish of the same species, and in general forage species appeared to be more seriously affected than common game species.

One- to three-mile sections of cold-water and warm-water streams were sprayed experimentally by airplane at the 1-pound dosage to determine the effect on fish and fish-food organisms. The spray was applied in one swath by a small plane flying directly over and parallel with the stream. The insects in the riffle areas at the lowest stations in a Pennsylvania stream showed a 90 percent reduction. Most of the May flies were eliminated. Certain invertebrates (worms, snails, dragonfly naiads, water mites, and some coleopterous, fish fly, and dobsonfly larvae) appeared to be unaffected by the spray. Stream insects become re-established rapidly, and within a year certain species of May fly and midge larvae had become exceedingly abundant. These species have a short life cycle and doubtless became re-established soon after the residual effect of the poison was dissipated. Although the aggregate numbers of insects had equaled, if not surpassed, the prespray level, several of the more susceptible species failed to attain their original numbers.

It was estimated that 1.3 percent of the brook trout population was killed. Warm-water species in the lower part of the stream were affected within twelve hours after the spraying. They included fallfish, common shiners, common suckers, and golden shiners.

A section of a smallmouth black bass stream in West Virginia was sprayed to determine the difference in effects with two formulations of DDT applied at the 1-pound rate. A surface film of DDT in oil caused marked reductions in the numbers of surface Coleoptera and Hemiptera, whereas a DDT suspension caused only limited kills in these groups. The oil solution killed 90 percent of the bottom organisms at the lower stations, and the suspension about 70 percent. Both sprays appeared to eliminate May flies, but a year later they were present in pretreatment numbers. Other insect groups were not affected so drastically by either formulation.

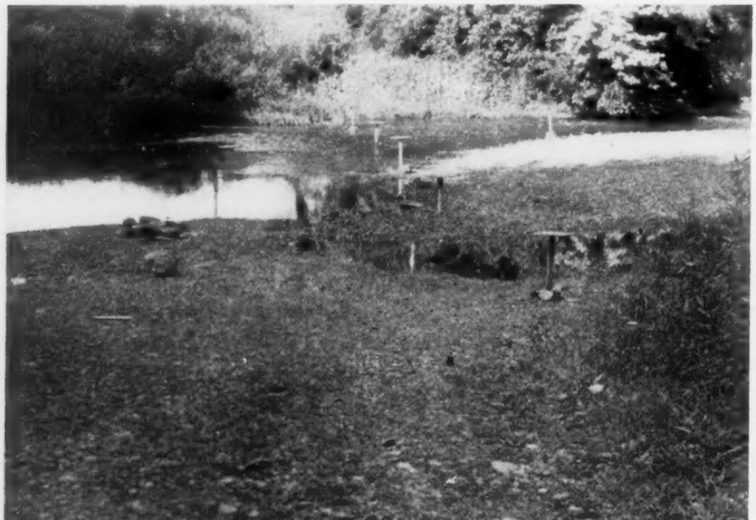
Although minor losses of small fish occurred after both sprayings, the oil spray killed more fish and in a shorter time than did the suspension. Only the oil spray was lethal to adult fish. Spotfin shiners, silverling minnows, and fallfish were noticeably affected by the oil spray, whereas bluntnose minnows, chub suckers, and pickerel were affected only slightly.

A ⅜-mile section of a small creek in the Teton National Forest was sprayed at the rate of 2.5 pounds of DDT per acre. This creek contained a series of active beaver ponds and supported a large population of cutthroat trout. Only 11 trout and about 50 percent of the bottom organisms were killed. The surprisingly small amount of damage incurred as a result of a fairly heavy dosage of DDT was probably due to the nature of the stream. Beaver dams slowed the flow of water so that there was little mixing of the spray, and the stream, which contained much organic debris, was muddy from beaver activity. Other studies indicated that the toxic action of DDT may be reduced under such conditions. It is also possible that cutthroat trout, in common with other species of trout, may be less susceptible to DDT poisoning than are some other fresh-water species. However, May fly survival in the lower part of the stream suggests that the biological and physical conditions of the stream reduced the residual potency of the DDT.

In connection with the program in Idaho for control of the Douglas-fir tussock moth in 1947, studies were made of the effects on aquatic life. Several species of trout (rainbow, eastern brook, and cutthroat), speckled dace, and red-sided bream were unaffected by the 1-pound per acre application of the poison, but cottoids, mountain suckers, and black catfish suffered heavy losses in limited areas. Crayfish, paralyzed by DDT, comprised 99

percent of the stomach contents of 21 brook trout, whereas no crayfish were found in stomachs of fish from untreated areas. The loss of fish-food organisms amounted to 50 percent in one locality. Elsewhere fish-food organisms were practically eliminated from riffle areas, but even in fast-moving streams the effects did not extend far below the sprayed areas.

After the experimental aerial spraying with DDT (1 pound per acre) for the control of the gypsy moth in Pennsylvania in 1948, 70–90 percent of the stream insects in two watersheds were destroyed within three days. That affected insects were fed on extensively by different fish was confirmed by direct observations and examination of stomach contents. Several species of fish of various sizes were killed by the spray or spray drift on ponds, lakes, or streams, particularly where there was double spray coverage. Species most affected in one artificial lake were golden shiners, pumpkinseed sunfish, and yellow perch. Stream species found dead were mostly the common white sucker and brook trout. These studies indicated that few fish in comparison with their total populations were killed in either the lakes or the streams. In some locations, however, only spray drift was involved. Although bottom organisms were drastically reduced in the streams, extraordinary numbers of midge larvae and lesser numbers of surviving invertebrates were present two months after the spraying. Fish seined at this time appeared to be in good condition.



Filter-paper station across a riffle area in a stream caught DDT, which was later analyzed chemically. Amount recovered was correlated with effects on aquatic insects and fish. *Below:* Weir installed on a stream to stop fish killed by DDT and washed downstream.

DDT AND ANIMAL-POPULATION RELATIONSHIPS

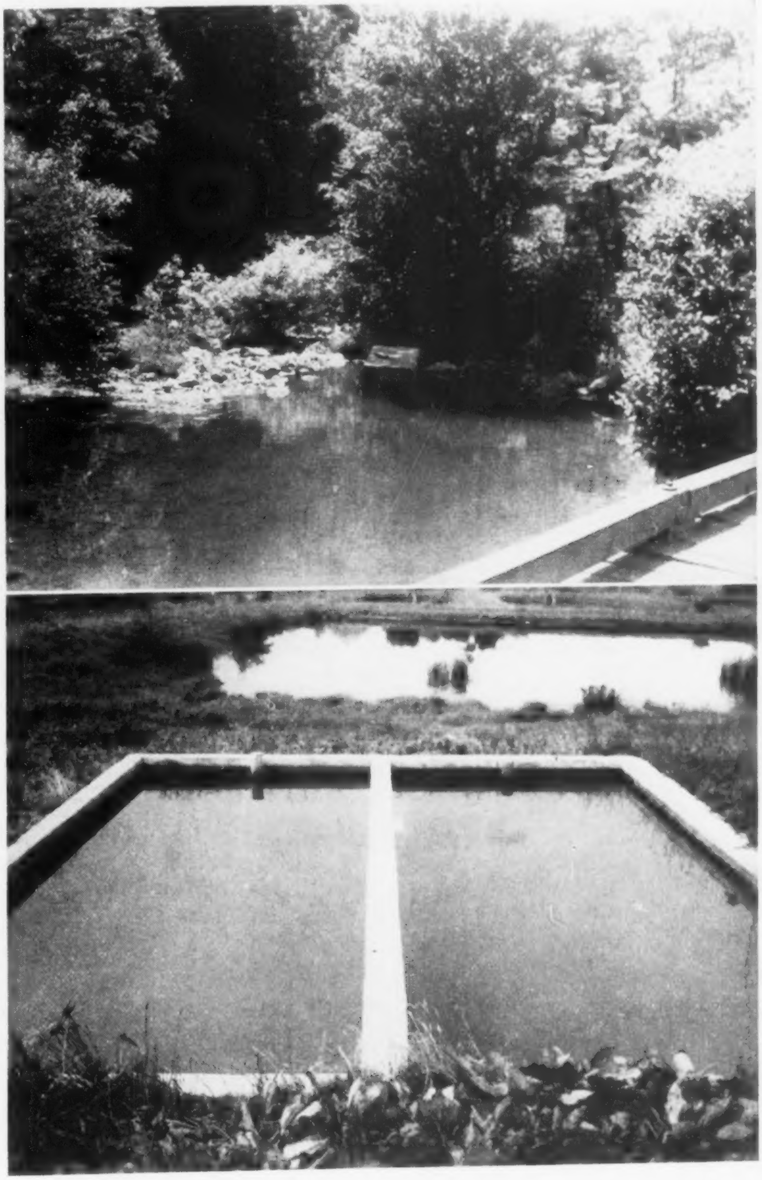
To understand the maze of interrelationships existing in wild populations challenges the ingenuity of ecologists even where conditions are little disturbed. The additional complications that control measures provide increase the difficulty of evaluating the status of many species. In these studies it has not always been possible to distinguish between effects of insecticide application and other changes arising through the normal procession of ecological events. This much, however, seems to be true of most control measures with DDT: Even with applications of a fraction of a pound per acre there is usually a temporary reduction in the numbers of susceptible invertebrates. In forest areas there has been no indication that such a result has caused either a marked or permanent change in the welfare of vertebrates, or in the economy of the

woodlands in general. Although application of the insecticide during the most vulnerable life-history stage of the pest insect can effect a long-time reduction of this species, the effects on gross insect populations appear to be transitory. The sprayed territory is rapidly repopulated by the continual emergence from life-history stages inactive at the time of spraying, and possibly by some invasion from untreated areas. Such observations appear to apply generally with dosages not exceeding 1 pound of DDT per acre.

In aquatic locations a more or less parallel situation has been noted. In these habitats, however, the organisms have opportunity for a more thorough and continuous exposure to the insecticide, and the over-all biological effects are greater. Even in these situations some re-establishment of invertebrates has been apparent in about two months. As would be expected after any general and heavy mortality, regardless of the cause, qualitative differences are apparent in the newly recovered population. Frequently the more prolific forms, midges in particular, predominate in the community. Within a year the variety and number of invertebrates may be at least as great as before spraying.

Of especial interest in these studies has been the constant reminder that a consideration of dosages alone is entirely inadequate for an interpretation of the probable hazards of DDT control operations. Instances have been discussed in which the time of insecticide application and size of treated area were found to modify considerably the effect of a given treatment on bird populations. Under conditions of actual control, weather and certain characteristics of the aquatic environments were also found to minimize markedly the effects of treatment on the fauna. Other observations in the field and laboratory have shown how such factors as the type of formulation and method of application may operate singly or in combination to modify results. Although such variables contribute greatly to the complexity of the problem, they also add encouragement to the prospects of reducing operational hazards by a proper attention to their importance.

The widespread adoption of DDT has prompted various estimates of the hazards involved. Some individuals, interested only in seeing this season's crop brought safely to harvest, refuse to recognize any possibility of dangers or disadvantages in its use. Others, who seemingly visualize static rela-



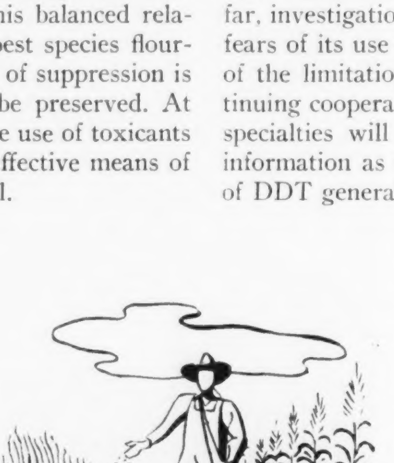
Live boxes containing known numbers of several kinds of fish were placed in quiet sections of streams, and controlled experiments of different DDT formulations and dosages were conducted in concrete daphnia ponds and dirt-bottom ponds at the U. S. Fish-Cultural Station, Leetown, W. Va.

tionships among living animals, speak vaguely of DDT upsetting the "balance of nature." For wilderness areas, particularly, they urge that control with such materials as DDT be abandoned in favor of natural balances, which they intimate will result from a laissez-faire policy. Neither of these attitudes, of course, represents an intelligent appraisal of the problem. Irresponsible thinking of the first type has resulted in many dust bowls and muddy rivers. The other viewpoint, professing a childlike faith in what nature will provide, is equally in error for its failure to consider realities.

Biologists, and others who have given attention to the dynamics of animal numbers, recognize many designs in the functioning of populations. Insect pests of the forest, for instance, have many natural forces tending to maintain some equilibrium in their densities. During all stages of their life history parasites and predators of their own kind exact a heavy toll. Vertebrates of many species make further inroads on their numbers, and various meteorological phenomena have a further controlling influence. Periodically, however, conditions arise which disturb this balanced relationship, one or another of the pest species flourishes, and some additional means of suppression is required if the woodland is to be preserved. At our present state of knowledge the use of toxicants such as DDT is often the most effective means of bringing such pests under control.

For many types of control the immediate gains financial or otherwise, are well defined. With some insects of medical importance, and pests of great economic concern to agriculture, the biological hazards of control compare with a different set of values than would be the case, for instance, in suppression of some forest-insect pests. In the latter case the crop may be of comparatively low monetary value and produced in areas of a more direct multiple-use nature. Here the occasion probably is greatest for measuring benefits of control against hazards to recreational and other interests.

There are still many unknowns regarding the biological effects of new insecticides and the many new economic poisons. With reference to DDT, and its remarkable stability under some conditions, one of the most critical needs is for a better understanding of the hazards implied by possible cumulative action. Studies now under way should bring enlightenment regarding this possibility, not only as it could affect humans and wildlife populations but, fundamentally, the soil and plant life. Thus far, investigations have served to allay many early fears of its use out-of-doors, and to indicate some of the limitations. It is very likely that the continuing cooperative studies by biologists of various specialties will be productive of such additional information as is necessary for a circumspect use of DDT generally.



URANIUM RESOURCES

J. K. GUSTAFSON

Formerly adviser to the U. S. Metals Reserve Company, Dr. Gustafson (Ph. D., Harvard, 1930) is manager of Raw Materials Operations, U. S. Atomic Energy Commission. This article is based on an address made by Dr. Gustafson at a Metallurgic Colloquium, which was arranged by Professor A. M. Gaudin, of the Department of Metallurgy, Massachusetts Institute of Technology, and held in Cambridge on March 9, 1949.

HOW does uranium occur in nature? Is there enough uranium to sustain an atomic energy program directed toward tools of peace as well as weapons of war? What is being done in this country to provide a continuing supply of uranium?

In spite of the necessary restrictions placed upon any public discussion of uranium resources, I shall make an effort to answer these searching questions as fully and as comprehensively as possible. Only in this way can we see the problem of wise administration of atomic energy and a sound foreign policy in the proper light.

How does uranium occur in nature? Genetically, uranium occurrences can be divided into four main types: igneous rocks, hydrothermal vein deposits, sedimentary rocks, and deposits of doubtful and perhaps complex origin. Certain oxidized deposits may be considered either as a fifth type or as a variant of the four basic types.

Uranium occurs in trace amounts in most igneous rocks but is concentrated notably in granitic rocks. It occurs in granites in concentrations in the order and magnitude of 0.00003 percent–0.0007 percent. Uranium occurs in granites chiefly in the accessory minerals monazite, xenotime, and possibly zircon. Granitic pegmatites rich in potash feldspar, however, may contain pitchblende, autunite, and other uranium minerals in visible amounts. Some pegmatites, like other uranium ores, have been mined in the past for radium (it is generally considered that radium is in equilibrium with uranium in the ratio of $3.4 \times 10^{-7} : 1$). In general, however, pegmatites are not a large potential source of uranium because the average grade is low, seldom exceeding 0.01 percent U_3O_8, and the tonnage is usually small. There may ultimately be amounts of uranium recovered as a by-product of feldspar or mica mining.

A decided preference of uranium for granitic rocks and acid pegmatites, and the grouping of some of the hydrothermal uranium deposits around granitic intrusions, clearly indicate that granitic magmas are the great primary source of uranium in the earth's crust.

Mesothermal pitchblende veins have yielded most of the uranium and associated radium that have been produced in the world. There are two main types of these:

1. Veins mined principally for lead, zinc, copper, gold, and silver, such as the veins of Gilpin and Boulder counties, Colorado. Pitchblende occurs in these as narrow streaks and patches. Veins of this type have contributed little uranium to world supply.
2. Veins containing cobalt and nickel minerals, in addition to other base metals and minor amounts of gold and silver. It is veins of this character that have produced the famous radium-uranium mines of Great Bear Lake in Canada, the Belgian Congo, the Erzgebirge region of Saxony and Bohemia, and the Cornwall district of England. The three most productive uranium-radium mines of the world are Joachimsthal, Bohemia; Eldorado in Canada; and Shinkolobwe in the Belgian Congo.

Some of the principal features of these three deposits are the following:

1. Each occurs as veins in pre-Cambrian sedimentary rocks.
2. The ore in each case is pitchblende associated with cobalt. At Eldorado and Joachimsthal nickel, bismuth, and silver are also present, whereas at Shinkolobwe molybdenum, thorium, tungsten, gold, platinum, and palladium are mentioned, as is lead at Eldorado.
3. In each case the principal nonmetallic gangue minerals are quartz and carbonates. Hematite, chlorite, barite, and fluorite also are prominent at Eldorado.

Some hypothermal quartz veins also contain small shoots of pitchblende, but these are relatively unimportant.

Marine sediments in many parts of the world contain uranium in low concentrations but in concentrations many times that of other rocks. Notable in this regard are black shales, and phosphorites. A number of these formations contain 0.01 percent–0.02 percent U_3O_8, and at least one—the alum shales of Sweden—contains nodules and lenses of a nearly pure bitumen called *kolm* which,

according to published figures, contains 0.5 percent U_3O_8.

Marine uranium-bearing black shales are characterized by abundant organic matter and sulphides and by small content or absence of carbonate material. The beds richest in uranium occur in thin formations of pre-Mesozoic age. The mineral or compound containing the uranium in these black shales has not yet been identified.

Probably all marine phosphorites contain some uranium, and phosphatic nodules in many marine black shales also contain concentrations of uranium. Although the form in which uranium occurs in phosphorites is unknown, the fact that uranium increases in a general way with increase in phosphate content suggests that the uranium may occur in the space lattice of the phosphate mineral. The phosphorite formations, like the black shales, are characteristically thin and are generally associated with unconformities, or diastems. These facts of occurrence have indicated to the men who have studied them that these uraniferous formations were deposited in large basins adjacent to low stable land masses during periods when mechanical erosion was at low ebb and chemical conditions in the sea water inhibited the formation of lime deposits. Very possibly those marine sediments derived from granitic land masses are the most highly uraniferous.

Two main types of uranium deposits are not yet properly classifiable. These are the vanadium-uranium ore deposits occurring on the Colorado Plateau and in lesser amounts in other parts of the world, and the Witwatersrand gold-bearing conglomerates of South Africa. The carnotite and roscoelite-type uranium-vanadium ores of the Colorado Plateau occur as small tabular or lenticular deposits impregnating the flat-lying Morrison sandstone and Entrada sandstone of Jurassic age and the Shinarump conglomerate of Triassic age. They are widely but spottily distributed over an area nearly two hundred miles in diameter. The long axis of the deposits, many of which do not contain more than several hundred tons of ore, are nearly parallel to bedding, but the ore does not follow the beds in detail. The mineralogy of the ores is very imperfectly understood. The deposits contain several times as much vanadium as uranium, and the bulk of the vanadium occurs in extremely fine-grained minerals of micaceous habit, probably belonging to the hydrous mica group of clay minerals. The principal mineral has been recognized tentatively as roscoelite. The principal uranium-bearing minerals are thought to be carnotite and tyuyamunite, sometimes called calcium carnotite. The theories of ore deposition subscribed to by most geologists are either: (*a*) that the ore was precipitated from ground water after the enclosing sands had accumulated, or (*b*) that the vanadium-uranium content was deposited during deposition of the enclosing rocks but was widely distributed in them and has experienced considerable subsequent movement and reconcentration by ground water. Small variations in bedding and sedimentary features of the rock appear to have guided the movement of ore solutions, with resulting concentration of the ore. Fossil logs and twigs are often completely replaced by ore and are further evidence that carbonaceous material generally is a precipitant for uranium. These types of ore bodies show a considerable range in both uranium and vanadium content and also a considerable range in the uranium-vanadium ratio. Much of the ore contains anywhere from 0.1 to 0.3 percent U_3O_8 and from 0.5 percent to 2.5 percent V_2O_5, although small tonnages of very much higher grade ore are mined from time to time. These deposits constitute the largest readily available source of uranium in the United States but a source greatly inferior to the high-grade hydrothermal pitchblende deposits of other countries.

Recently, along the southwest and western edges of the Colorado Plateau, numerous new prospects of uranium (carnotite)-copper ores in the Shinarump conglomerate have been found which are similar in size and occurrence to the uranium-vanadium ores. Whether these will be important producers is not yet clear.

The Witwatersrand reefs are extensive beds of metamorphosed quartz conglomerate. It has been known for many years that the gold ores contained small amounts of uraninite, but only recently has the possibility of by-production of uranium from this source become apparent. A controversy has raged for many years over whether the gold ores had a hydrothermal or a sedimentary origin. The origin of the uranium in this conglomerate is equally in doubt, but it may not necessarily be the same as that of the gold.

In Canada, where glaciation stripped off any old oxidized soil covering that existed, primary uranium minerals but slightly oxidized occur at the surface. In countries like Africa and Australia, however, primary products are oxidized to depths of hundreds of feet. Here pitchblende, which is a black, heavy, metallic mineral, has been converted in the zone of oxidation to brightly colored secondary minerals, such as torbernite, a bright em-

erald-green hydrated phosphate of copper and uranium; autunite, a lemon-yellow hydrated phosphate of calcium and uranium; or carnotite, the canary-yellow hydrated vanadate of potassium and uranium. As is the case with copper ores, a colorful, flamboyant outcrop does not necessarily mean good primary ore in depth.

Is there enough uranium to sustain an atomic energy program directed toward tools of peace as well as the weapons of war? The answer to this question involves an appraisal not only of the actual quantity of uranium that man can win from the earth's crust if he bends every effort toward this purpose, but also the value of uranium or the measure by which man limits his effort to recover uranium. Recently a number of distinguished men in scientific fields have made some guesses as to the availability of uranium and have come up with gloomy answers. One of these prophets has concluded that there never will be "an atomic age." Another believes that the use of uranium for atomic power will be extremely limited. Before answering the question, let us examine the comparative value, in terms of energy, of uranium and other substances.

According to the Smyth Report, if all the atoms in a kilogram of U-235 were to undergo fission, the energy released would be equivalent to the energy released in the explosion of about 20,000 short tons of TNT. We have had dramatic and terrible demonstrations at Hiroshima and Nagasaki of the power of uranium as an explosive. The bombs dropped on Japan had more than 2,000 times the blast power of the British "Grand Slam," up to that time the largest and most destructive bomb ever made. Clearly, uranium is here to stay as a weapon, but we are concerned at the moment with appraising it as a fuel for peacetime energy.

The consumption of about one pound per day of uranium 235 in fission generates heat at a rate equivalent to approximately 450,000 kilowatts, which is the amount of heat that would be obtained by burning about 1,300 tons of coal per day. Even with low efficiency, uranium 235 is obviously a very potent source of power. Although in naturally occurring uranium only one part in 140 is the fissionable isotope uranium 235, by a process known as "breeding," it is theoretically possible to combine some additional uranium 235 with natural uranium and to convert the nonfissionable uranium 238 into fissionable plutonium. By this process, to quote from J. R. Menke's "Nuclear Fission as a Source of Power," "for each pound of fissioned (burst) uranium 235 together with one pound of ordinary uranium we get (*a*) about ten million kilowatt hours of energy in the form of heat, (*b*) about one pound of fissile element (e.g., plutonium) and (*c*) about one pound of new radioelements." This is of the order of about three million times the energy released by the burning of an equal weight of coal. This strange process of eating your cake and having it too is theoretically applicable not only to uranium 238 but also to thorium, the use of which would increase available atomic fuel manyfold.

The experts, in groping for an estimate of the amount of uranium available, have approached the problem from two directions. One is to take the average uranium content of a great many samples of rock of different kinds and to conclude that the resulting figure of four parts per million, or 0.0004 percent, is the amount of total uranium available in the earth's crust. On this basis, you can come up with the answer of about 1.5 times 10^{12} tons of uranium in the one-mile layer of earth's crust not covered by water. It can be pointed out on this line of reasoning that uranium is 1,000 times as plentiful as gold, 100 times as plentiful as silver, and almost as plentiful as lead or zinc.

To my mind, such an approach is meaningless except to indicate that uranium is an important material in the earth's crust and, accordingly, that it probably was present in the right places fairly often when geological concentrating processes were at work forming ore bodies. What counts in terms of available uranium is economically exploitable concentrations.

The second approach is to take some prewar figures of uranium production or, more generally, of radium production—calculate the amount of associated uranium from these, and assume that these figures and the ore-reserve data of that same prewar period are a valid measure of the potential production of uranium in the future. This appears to me an equally fallacious approach for the following reasons:

1. Even up-to-date ore-reserve data, whether they be for copper, gold, lead, uranium, or any other metal, mean very little unless one realizes that it has been proved historically time and again that such estimates merely show that only a few years of production are blocked ahead. It is not economically justified for most mining companies to spend more money in development than is necessary to maintain ore reserves for more than one to five years. It is often bad business to make capital investments in development work that will not yield returns for a long time to come. Moreover, in this country, mining companies have to pay taxes on their proved reserves, and this taxing policy inhibits unnecessary blocking out of reserves. Petroleum figures also

have periodically led experts to predict early exhaustion of our oil reserves. According to some early predictions, we should have run dry by now. Yet the American Petroleum Institute figures show an annual increase in the known reserves of petroleum in this country almost every year for a decade or more, despite increasing rates of production.

2. Also ignored or underrated in this approach are our growing technology and its future application to low-grade uranium sources. Most metals have gone through, or are going through, a cycle where high-grade deposits are at first the only commercial deposits, and then gradually large low-grade deposits yield to man's technical ingenuity and become important producers. This is strikingly demonstrated in the case of copper in this country. Not so many years ago, you had to have 2 percent copper to make a mine. At the present time, one of our copper mining companies has issued a prospectus calling for the financing to the tune of many millions of dollars of a primary copper ore body averaging less than 0.8 percent copper to be mined by underground methods. The "mining" of sea water during the war as an "ore" of magnesium is probably the most spectacular example of such a development. The ore-reserve-production data approach thus omits from consideration the vast tonnages of marine sediments or by-product production from the South African gold-mining industry. That this latter may be a serious omission is indicated by the statement made in a recent speech by the Minister of Industrial Production of the Union of South Africa, who said, "We believe that we are able to say that the Union of South Africa may produce more uranium than any other country of the world."
3. Neglected by this approach also is the great surge of prospecting for uranium that is going on in all parts of the world. After all, man has only just begun to look for uranium. Up until now it has merely been a by-product of the radium or vanadium business, useful in coloring pottery and artificial teeth. My guess is that new deposits will be found by this effort. Dr. W. F. James, of the Advisory Staff of the Canadian Atomic Energy Commission, in a recent talk before the American Institute of Mining and Metallurgical Engineers in San Francisco, announced that already three new properties in Canada are virtually certain to come into production, and that there are three or four promising new prospects in addition.

The commercial aspect of uranium should be kept in mind. The average uranium content of some granites is of the order of magnitude of 0.22 ounces per ton of rock. If we had that much gold in a large granite mass, we would consider it a very profitable mine. Of course, the price of gold is roughly 124 times that of uranium and, generally speaking, it is easier to extract. Nevertheless, if uranium extraction technology improves greatly, and if uranium is ever needed badly enough—i.e., its price is high enough—there will be a lot of it available.

It is pertinent to inquire, "What is uranium worth today to a mining company?" There may someday be established a world price for uranium comparable to but of different magnitude than the price of gold, but at present there is no such price. Foreign uranium is purchased at negotiated prices. The U. S. Atomic Energy Commission has established for domestic uranium a ten-year minimum price of \$3.50 per pound of contained U_3O_8 in a high-grade product, the Canadian government has established a roughly equivalent minimum price of \$2.75 per pound of contained U_3O_8 in Canadian ores and concentrates containing at least 10 percent U_3O_8 f. o. b. railroad, and the United Kingdom Ministry of Supply has offered to buy all uranium ores and concentrates produced in the Colonial Empire during a ten-year period at a minimum price of 13*s.* 9*d.* (approximately \$2.78) per pound of contained U_3O_8 delivered f. o. b. ocean port. Aside from these, I know of no other publicly announced prices for uranium since the development of atomic energy. As one can easily figure out, even a narrow pitchblende vein means high-grade ore at these prices.

Because uranium is everywhere controlled by the governments of the countries in which it exists, it is unlikely that it will ever appear on free competitive world markets in the sense that lead or copper does. In this connection, attention is called to the fact that the Commission's ten-year guaranteed minimum price for domestic uranium is in fact a minimum price. Where larger quantities are involved than the small lots for which this price was established, or under special circumstances, the Commission is prepared by negotiation to establish higher prices which will take into consideration special milling and refining costs, etc.

There is, moreover, at the present time a "subsidy" price in connection with our Colorado Plateau ore-buying program. There is a base price (including development allowance) of \$2.50 per pound of contained U_3O_8 in ores containing 0.2 percent U_3O_8, but payment is also made for the V_2O_5 content at 31 cents per pound, and a haulage allowance of 6 cents per ton mile is allowed up to a limit of 100 miles. Additional premiums are allowed for higher-grade material. It is hoped that private prospecting resulting from this program and the attendant exploration program of the government will sustain a mining industry and will add materially to domestic reserves.

For security reasons, I have had to discuss this subject without divulging much quantitative information as to known reserves or rates of production. For reasons already stated, however, information of this kind is insufficient to measure

future possibilities. In my judgment, the estimates of future uranium supplies that I have seen are far too pessimistic. I shall be content to rest my own case as a prophet on the prediction, based principally on mining experience with other metals, that there will be new high-grade uranium producers found, that the old producers will last longer than people think, that there will be significant uranium production from low-grade ores that are not now even considered ore, that we can get large amounts of thorium when and if we need thorium, and there will be enough source material to permit the use of atomic energy to expand considerably and to go on for generations.

What is being done in this country to provide for a continuing supply of uranium? During the war, the Manhattan Engineering District purchased foreign uranium from Canada and the Belgian Congo and extracted uranium from accumulated tailings of past vanadium operations on the Colorado Plateau. The Atomic Energy Commission took over the atomic energy project from the Army at midnight, December 31, 1946. The Commission has continued to buy foreign uranium, which to this day constitutes a high percentage of our total plant feed. The Commission on April 11, 1948, also announced a three-point program to stimulate the discovery and production of domestic uranium by private competitive enterprise. The major elements of this program are:

1. Government-guaranteed ten-year minimum prices of \$3.50 per pound of contained U_3O_8 for small lots of domestic refined uranium, and of \$3.50 per pound of recoverable U_3O_8, less refining costs, for small lots of ore or mechanical concentrates assaying at least 10 percent U_3O_8, both prices f. o. b. shipping point.
2. A bonus of \$10,000 for the discovery of a new deposit and production therefrom of the first 20 tons of uranium ore or mechanically produced concentrates assaying 20 percent or more U_3O_8.
3. Guaranteed minimum price for uranium-bearing carnotite-type or roscoelite-type ores of the Colorado Plateau area for the period ending June 30, 1954 (Circular No. 3, which extended through April 11, 1951, and Circular No. 4, which extended through June 30, 1949, were combined in new Circular No. 5 on February 1, 1949). Although no important change was made in the pricing provisions of circulars No. 3 and No. 4, several adjustments were made, and the period of the guarantee was extended for approximately three years in order to attract capital and mining development.

The Commission also has extensive exploration activities that are carried out largely by the U. S. Geological Survey. These activities include:

1. A comprehensive geological study and exploration of uranium-vanadium ores of the Colorado Plateau.

2. A comprehensive geologic study of the uranium-bearing phosphate and shale formations of the country.

3. A systematic examination of all mine dumps, mill tailings, smelter slag, and similar products for radioactive minerals.

4. A systematic study and frequent logging of oil and gas wellholes for evidences of radioactive material.

5. Reconnaissance studies of so-called geologically favorable areas for evidences of unusually radioactive materials.

6. Spot examinations of all reported uranium prospects believed to have some chance of being important.

7. Geologic reconnaissance of river placer and beach sand deposits to locate large potential sources of monazite for use if thorium becomes a fuel for nuclear reactors. (The U. S. Bureau of Mines is following after the Survey with engineering cost studies.)

8. Examination of pegmatites as possible sources of uranium and beryllium. (Beryllium is one of several substances that can be used as a moderator in an atomic reactor.)

9. Special studies in connection with existing or proposed nuclear reactor sites, such as Hanford, where there are big and complex problems associated with water supply and waste disposal.

10. Laboratory studies of many kinds involving the mineralogy and chemistry of uranium, and never-ceasing research on the improvement and development of radioactive instruments and techniques.

An equally important part of the Commission's study of uranium resources is its research program to develop new processes which can treat economically the very low-grade uranium materials I have described. Massachusetts Institute of Technology has played and is continuing to play an important part in this program. We are very optimistic about the outcome of this program, although there are many fascinating but difficult minerals-engineering problems yet to be solved. Incidental results of this program, which are nevertheless important, have been the development of new and improved analytical techniques and instruments.

The Atomic Energy Commission, required by the Atomic Energy Act, also licenses all transfers of source material after its separation from the place of deposit in nature. (The term "source material" means any material except fissionable material containing 0.05 percent or more of uranium and/or thorium.) Consequently, anyone buy-

ing or selling uranium or thorium ore after it has been mined must apply to the Commission for a license. Distributors and processors of source material are also required to fill out a simple form each month so the Commission can have a record at all times of where it is and where it goes.

What is the outlook in the uranium industry for students of mineral engineering? At the present time, probably not more than four hundred professional geologists, mineralogists, metallurgical and chemical engineers, and mining engineers are directly engaged in this country's raw materials' program having to do with uranium ores. Most of these are employed by the government agencies or by contractors having research contracts with the Commission. A comparatively small number employed by private companies are engaged in producing uranium and vanadium. It should be remembered, however, that this is an infant industry, which will grow if the present exploration efforts are successful. The program of the U. S. Atomic Energy Commission is firmly based on the assumption that new uranium deposits can best be found, developed, and worked by individuals and private companies seeking profits. Canada has embarked on a similar program emphasizing the opportunity for private enterprise. As new low-grade materials are developed as a source of uranium, it will be mineral engineers who develop them. I am optimistic as to the future. The uranium industry may never employ as many mineral engineers as the copper industry or the gold industry, but I strongly recommend that young mineral engineers, especially, maintain a constant professional interest in uranium as a new metal of enormous significance to this and succeeding generations.

TO A RAINSTORM

Fling down your curtain of splintered spears.
Release your barrage of explicit tears
That break with outraged sputtering
On grass and sea and stone. Here is
A face upturned, unsheathed; a need
Upon it for each clean, clipped bead;
An urge to feel this pristine thing
Born of no hand, no mill, no seed.

Rose Richman Unger

ESP—FACT OR FANCY?*

ROBERT A. McCONNELL

Dr. McConnell is assistant professor of physics at the University of Pittsburgh. In the field of electronics he has contributed to the development of pulsed Doppler radar and to the theory of the iconoscope. He began the study of the literature of extrasensory perception as relaxation from his wartime research duties, and has since become convinced that the evidence for this phenomenon is good enough to warrant serious consideration by scientists.

THE term "extrasensory perception" has achieved acceptance in the lay vocabulary largely because of the efforts of Professor J. B. Rhine, of Duke University. As a result, it is widely supposed that the phenomenon was discovered by Rhine and that no significant evidence for its existence has been obtained except in Rhine's laboratory. It will surprise many to learn that one might ignore the Duke work without seriously impairing the evidential status of the phenomenon.

SOME EARLY CARD EXPERIMENTS

The work begun at Duke University in 1930 was carried out by means of the "ESP card deck." That deck consists of cards printed with one of the five symbols shown in the accompanying illustration. The standard deck contains a total of twenty-five cards, there being five cards of each symbol.

At first thought, the use of playing cards for the investigation of extrasensory perception might seem a foolish procedure unworthy of a serious investigator. The long association of cards with frivolity and legerdemain does not help to dispel the deep-rooted skepticism that most scientists feel about telepathic phenomena. It is only upon closer examination that the elegance of the card deck as a research tool becomes apparent. Its merits are its susceptibility to experimental control and its sensitivity to slight traces of extra-chance causation. Experimental control is easy because of the simplicity and dependability of the "apparatus." The sensitivity of cards as a tool arises from the use of probability mathematics.

Card calls with the ESP deck can be treated as independent trials with constant probability. The binomial distribution applies with a small correction to the standard deviation necessitated by the fact that in the deck there are known to be exactly five of each symbol.[1] The adequacy *ad hoc* of the statistical methods used in the demonstration of ESP has been attested to by prominent mathematicians.† The mathematics of the cards has ceased to be a point at issue.

A number of outstanding experiments have been performed with the ESP card deck. One of the first of these in point of time and interest is the series of tests given to the subject Hubert Pearce with the cards in one building on the Duke University campus and with Hubert Pearce himself in another.[2] Dr. J. G. Pratt (then a graduate student in psychology) was the principal experimenter throughout the series. Dr. J. B. Rhine witnessed Pratt's handling of the cards in one subseries (in which the scoring rate was well above the average for the rest of the series). The experimenter and subject worked by synchronized watches and without means of communication. The above-described card deck was used: twenty-five cards, five each of five suits. Two runs (fifty trials) were made per day. The cards were shuffled just before using and, of course, with HP absent from the room.

Starting on schedule, once each minute Pratt would remove the top card from the deck and lay it face down on a book in the center of the table without looking at its face. The subject located in another building would record his "impression" of the card 30 seconds later. The cards were recorded by Pratt after completing the runs. Sealed records from the observer and subject were delivered directly to Rhine at the end of each sitting.

A total of 1,850 trials was made under these conditions. The expected mean score was 5 out of

* Publication 3p48 from the Physics Department of the University of Pittsburgh.

† Dr. B. H. Camp, former President, Institute of Mathematical Statistics; Dr. R. A. Fisher, University of Cambridge, England; Dr. J. A. Greenwood, Senior Statistician, U. S. Navy Bureau of Aeronautics; Dr. T. N. E. Greville, U. S. Bureau of the Census; Dr. E. V. Huntington, Department of Mathematics, Harvard University.

25. The actual mean score was 7.53 out of 25. This deviation is 10.8 times the standard deviation. The probability of such a score by chance alone is less than 10^{-20}.

This test was repeated by Dr. Bernard F. Riess, assistant professor of psychology at Hunter College, using another subject.[3-6] Riess began as a skeptic and undertook the following experiment after preliminary classroom trials had shown extra-chance results.

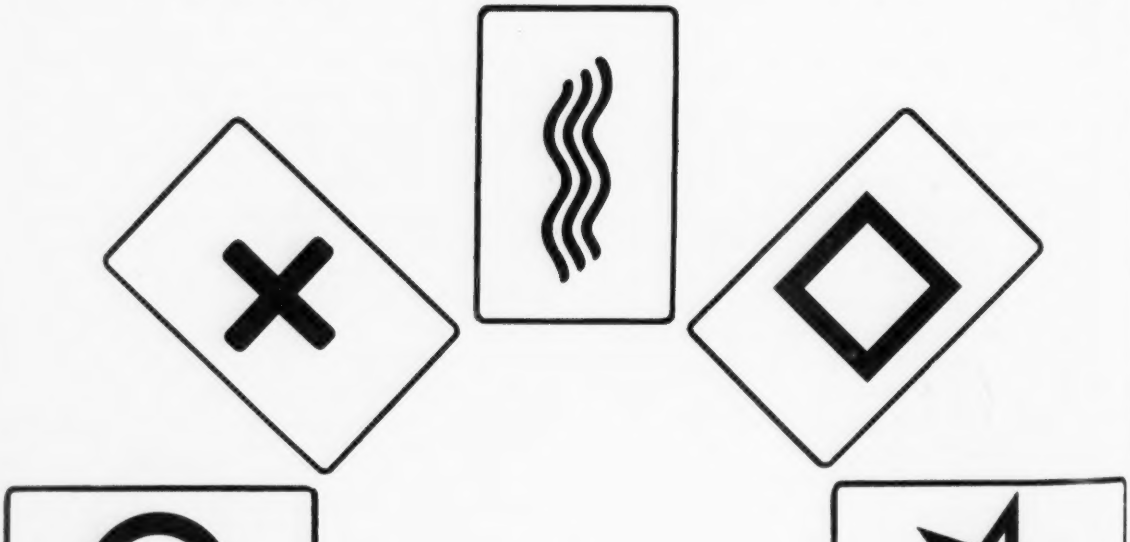
The subject, a Miss S., and the experimenter, Dr. Riess, worked in their respective homes in White Plains, New York. The houses were one quarter mile apart, and their rooms faced away from each other. Beginning at the appointed time, Riess exposed the cards from a shuffled ESP deck at one-minute intervals. He recorded each card as he exposed it, and the subject recorded her guesses on schedule. During the day following each session the subject's record was mailed or delivered to Riess. Fifty trials were made per evening over a period from December 27, 1936, to April 1937, until a total of 1,850 trials had been reached. The average score was 18.24 out of 25. There is no need to apply statistics to such a score to recognize its extra-chance character.

A third experimental series of great evidential strength[7] was that conducted by Dr. Lucien Warner, now professor of biology and psychology at Claremont Men's College (California). Warner arranged this test as a definitive answer to the critics of earlier work. The test took place on October 8, 1937, at Greenfield, Massachusetts.

The subject, MH, was locked in a room on the first floor. The experimenter and his assistant, Mrs. Mildred Raible, occupied a room on the second floor not directly above the subject's room. The doors to both the experimenters' and subject's rooms were closed throughout the experiment; moreover, the rooms were so oriented that even had they been on the same floor, one door could not have been seen by a person standing in the doorway of the other. The experimenters did not talk or whisper to one another during the course of the experiment. A one-way signaling device was provided whereby the subject could flash a light in the experimenters' room to signify that she had written down her guess and was ready for the next card.

The total number of trials, 250, was fixed in advance. Each card was cut from a freshly shuffled full deck; thus, the probability distribution was strictly binomial. The card face was exposed and recorded *after* the subject indicated that she had made her guess. The average number of hits was 9.3 per 25. This score gives a deviation 6.8 times the standard deviation. The probability that this might occur by chance is about 0.000,000,000,064.

There have been other researches[8-10] from this same period whose experimental adequacy is



The "ESP deck" consists of five cards of each symbol—a total of twenty-five cards.

unassailable but not readily depictable in the space of a few lines. Reading the literature for the first time, the serious student will be surprised at the number and quality of the experiments that bear testimony to the existence of ESP.

RECENT ADVANCES

It is sometimes asked why there have been no more Riess and Warner cases in recent years. Such high-score tests under rigid conditions prove only one thing: they prove the existence of an anomaly in science. This anomaly has been given the name extrasensory perception. There are many people for whom the repeated observation of a strange phenomenon is not enough. They must acquire some degree of understanding before they can accept it as real.

In 1938 the evidence for ESP was already extensive. When the American Psychological Association held a symposium on ESP at Columbus, Ohio, two things were made clear: (1) The critics could find no fault with the many well-done experiments; and (2) the majority of psychologists were still unconvinced of the reality of this anomaly. The parapsychologists, as they have called themselves, then decided that all effort should be concentrated on learning more about ESP and that none should be wasted in further attempts to obtain high scores. The research results since that date have rarely been spectacular, but they are exciting and, in their own way, even more convincing than what was known before.

Despite the difficulties interposed by World War II, knowledge of parapsychology branched in several new directions. Recent research advances can be classified under four headings:

1. The systematic study of success-frequency trends within experiments.
2. The discovery of a covariation of sporadic ESP ability when a subject tries several ESP tests in immediate succession.
3. The discovery of a consistent misdirection or displacement of ESP aim to targets just before or after the desired card.
4. The correlation of ESP scoring ability with other psychological measures of personality.

SCORING SALIENCE

Estabrooks[11] reported from Harvard in 1927 that his subjects scored lower in the second half of a test consisting of twenty trials than in the first half. Through the years which followed it was gradually recognized that the rate of success in ESP experiments was likely to follow typical patterns. At the beginning of an experiment the scores were generally highest. Moreover, any one subject tended to improve temporarily with any change in the testing routine, however slight: a new size of card symbol; the beginning of a new data page; any slight change in the scoring procedure. Anything that introduced an element of novelty was found to raise the score—until the novelty wore off. It was found, too, that in those experiments in which the end of the task was given psychological prominence the scoring tended to rise as the end approached. A long list of investigations showed these effects.

Finally, it occurred to someone—or perhaps to a number of people simultaneously—that here was a new kind of evidence for ESP. Here was a secondary effect whose occurrence was a mark of authenticity in ESP data.

A systematic investigation of these effects was presented by Rhine[12] in 1941. Since that time the analysis for "salience effects," as they are called, has become a routine part of the treatment of ESP data. The major significance of salience effects in ESP derives from the fact that they are well known in many experiments in orthodox psychology. They are accepted as characteristic of the operation of the human mind in certain kinds of situations.

COVARIATION OF ESP ABILITIES

The covariation effect was first reported by Gardner Murphy and Ernest Taves of Columbia University[13] in 1939. ESP is known to be a sporadic and undependable ability. It occurs only with some subjects, only for some experimenters, and only at certain times. Under unfavorable experimental conditions it sometimes even reverses itself, giving extra-chance low scores when high scores are desired. Knowing these difficulties, one might ask the following question: Suppose a subject is given two tests at the same sitting. Suppose, for example, that he is asked to guess through an ESP deck and then immediately thereafter to identify cards from an ordinary playing card deck. Will he do well on the second task on the same days that he does well on the first?

In the tests of Murphy and Taves each subject was given four different tasks at each sitting. The subjects were picked more or less at random with no regard for their ESP scoring ability. Even though the final ESP scores were not significantly above chance when considered by themselves, it was found that a significant scoring correlation between tasks did exist;‡ that is to say, a poor ESP subject may still have occasional flashes or spurts

‡ This particular study should not be regarded as unquestionable evidence for ESP, since a rigorous evaluation of the data is beyond present-day statistical methods. *See* page 170, reference 1.

of ability that can be identified by his simultaneous improvement in several ESP tasks.

DISPLACEMENT

The third of four new kinds of evidence for ESP is the "displacement effect" discovered by Whately Carington and studied at length by S. G. Soal and K. M. Goldney. The story behind this work is one of considerable human interest.

For five years, beginning in 1934, Dr. Soal had sought unsuccessfully for a subject who could demonstrate ESP using the Duke card deck. Soal was a teacher of mathematics at the University of London, and most of his tests were conducted at that University. During the period in question he had tested 160 subjects and recorded 128,350 guesses. It was natural under such circumstances that he should have been suspicious of the successful work done in the United States. His freely expressed criticisms and doubts are now a matter of record.

Meanwhile, Whately Carington, working in Cambridge, England, had made an unusual discovery. Using drawings as ESP test material, Carington found that subject's reproductions tended to correspond sometimes with the originals for which they were intended but more often with other originals presented in the same series. Carington thereupon suggested to Soal that he rescore his unsuccessful card tests, not for the intended card, but for cards immediately preceding and following. In November 1939, after repeated urging, Soal did just that. To his surprise, he found two out of his 160 subjects who showed an extremely extra-chance displacement score.[14] During 1941–43, Soal and Mrs. K. M. Goldney carried out a study[15] with one of these two subjects, Mr. Basil Shackleton. The probability of chance as an explanation for the results obtained has been calculated as 10^{-35}.

This two-year study has many features of interest. The experimental conditions were ironclad both as to sensory cues and recording errors; moreover, throughout the tests there were always two or three witnesses present in addition to the agent and the subject. This study has been reviewed in greater detail by G. E. Hutchinson in *The American Scientist*.[16] The subsequent criticism of that review[17] offers considerable insight into the scientific status of extrasensory perception.

ESP AND PERSONALITY

The fourth kind of new evidence for ESP is undoubtedly the most important in terms of future promise. ESP ability is a vagrant, unpredictable thing. Why do some people have it and others not? Are good subjects more prevalent among the young or the old, among men or among women? Is there perhaps something peculiar about people who can guess cards correctly? Is racial origin important? Do the insane have ESP ability? These and many similar questions have been asked. For the most part, the answers have been disappointing, although here and there suggestive results which need further investigation have occurred. Recently, however, a vein of pay dirt has been struck, so rich as to attract the major part of present-day investigative effort.

There are in psychology a number of tests designed to measure various aspects of human personality. The best known of these is the Rorschach ink-blot test. Another is the Elkisch expansion-compression measure of personality adjustment. At Duke University Dr. B. M. Humphrey has discovered[18] that in certain ESP drawing experiments, "compressive" subjects show a backward (post-cognitive) score displacement, whereas "expansive" subjects score best on the intended drawing. Similarly, at the College of the City of New York, Dr. G. R. Schmeidler has found[19] that ESP scoring ability can be correlated with several categories of the Rorschach test. The interpretation of these correlations is as yet far from clear, but as evidence for the reality and—even more important—the *normality* of ESP in the personality of the individual, they are landmarks in the growth of a new science.

The evidence for ESP is too extensive to be compressed into a single review. But, so far as it goes, what might one conclude from the above discussion of the literature of this subject? Does extrasensory perception occur?

To set this question in proper perspective it is desirable to refer to the definition which has been given to the term "ESP." Many people bear hostility to the expression "extrasensory perception," which is not justified by the limited meaning that has been attached to it by Dr. Rhine and his followers. In the glossary in the back of every issue of the *Journal of Parapsychology* this definition appears: "ESP: response to an external event not presented to any *known* sense." (Italics added.)

This definition does not imply anything about the nature of ESP beyond mere occurrence. To say that this effect occurs is only to say that there is no counterexplanation for those experiments

that have been offered as evidence. If it be tentatively assumed that the foregoing presentation has been fair and adequate, then is it possible to avoid the tentative conclusion that ESP does occur within the limited meaning of its definition? Beyond the question of mere occurrence many others might be asked. How does ESP tie into the current body of science? Is it *physical* in the sense that it has some lawful dependence upon time and space? Such questions lie beyond the scope of the present discussion. Although by now there is considerable evidence bearing upon these and similar questions, it can hardly be called conclusive in the sense that the evidence for the *occurrence* of ESP is conclusive.

Perhaps for most scientists it will be enough to know that here is a field for research which, like evolution and relativity before it, is slowly gaining acceptance. It is a new field, with new hopes and new opportunities. It will attract the attention of young men who are not afraid to invest their efforts in a speculative venture.

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SCIENCE ON THE MARCH

RECENT DEVELOPMENTS IN CUT FLOWER STORAGE AND SHIPMENT

CUT flowers, in common with most other horticultural products, are a perishable commodity, and the essentially transient character of many flowers has been a deterrent to their use on a large scale. The availability of rapid transport in recent years has caused an increased interest in the development of new methods of storage and shipment. Air transportation has stimulated the commercial production of outdoor-grown cut flowers in California, Florida, Hawaii, and other subtropical and tropical regions, but since some flowers are rather heavy in proportion to value, they are, accordingly, not well suited to long-distance transportation. In general, air transport does not involve serious problems due to altitude effects.

A considerable volume of detailed scientific information is available on the physiological processes of maturation during the commercial storage and transport of fruits and vegetables; very little is known, however, about the corresponding processes in flowers, except in barest outline. The course of respiration of flowers has not been charted accurately, and the relationship of respiration to keeping quality is not certain.

Flowers should be cut and handled in a manner that will prevent plugging of vascular elements. Sometimes the stems are too small or hard to permit the free passage of water; in such cases, splitting or mashing the bases of the stems is practiced. Weak disinfectants are used to prevent plugging due to bacteria and fungal action or to delay tissue deterioration, but these are not always beneficial. Vascular plugging may result from air bubbles, and in such cases wilted flowers can be revived by cutting off the stems under water. Hamner, Carlson, and Tukey have shown that some flowers may have their keeping qualities enhanced by immersion under water in a vacuum, a treatment which fills the intercellular air spaces with water.

Transpiration of flowers may be reduced by coating with certain materials, either by dipping or spraying; for example, a paraffin wax emulsion has been used by florists as a means of prolonging the life of floral arrangements under adverse conditions. Recently workers at Michigan State College have reported that certain flowers lasted longer when coated with a water-dispersible polyvinyl plastic. This material was not detrimental to the natural appearance of white flowers such as gardenias, and there was only partial loss of fragrance. The plastic was also shown to be a valuable aid in the preservation of green decorative foliage and Christmas trees.

One of the most commonly used methods of reducing the respiration rate of flowers is lowering the temperature by refrigeration. The optimal temperatures vary according to the kind of flowers, as might be expected. A few tropical flowers, such as certain orchids and anthuriums, are affected adversely when subjected to temperatures lower than 55°; most flowers keep quite well, however, at temperatures of 38°–42° F. To maintain reduced temperatures during shipment, refrigeration is provided by a combination of ice and solid carbon dioxide. A recent commercial development for refrigeration consists of frozen wet sawdust, combined with a hygroscopic salt, which provides the necessary low temperatures without leakage of water.

Another advantage of lowered temperatures is the reduction of ethylene production. Ethylene in very low concentrations has been shown to be the cause of fading in orchids, "sleepiness" in carnations, and other injuries to flowers. Trouble has sometimes arisen owing to the escape of artificial illuminating gas, which contains ethylene; common storage with ripening fruits which produce ethylene is dangerous. Flowers also produce ethylene, but little is known of the physiological effects of these emanations on the flowers.

Modified atmosphere storage using reduced oxygen tension and increased carbon-dioxide tension has aided the storage of certain fruits. Thornton, at the Boyce Thompson Institute for Plant Research, demonstrated that the use of an atmosphere with increased CO_2 concentration (5–15 percent) also prolonged the life of such cut flowers as gladioli, snapdragons, cosmos, dahlias, and carnations. The treatment was effective only on buds, and even in the bud stage some flowers showed no response. (High concentrations of CO_2 (30–80 percent) can change flower color.) The use of carbon dioxide has been successful in experimental studies on air transport in Europe and has been used in intercontinental shipments; the large air-

shipment industries in the United States, however, do not at present use it.

Another successful method of aiding flower storage is the use of sugar solutions to provide a substrate for respiration. This has been combined with a disinfectant to suppress microorganisms. Such preparations have had an extensive use by florists and have been used by wholesale florists on many flowers as a preshipping treatment. Neff has indicated that salts of cobalt, bismuth, lead, uranium, tin, and molybdic acid in sugar solutions mordant the flower color pigments, preventing fading or changing of color. By this means, flower colors may be stabilized.

Some preliminary studies with phytohormones such as alpha naphthalene acetic acid and similar compounds indicate that flower life may be prolonged and shattering prevented through their use.

Neff and Loomis showed the practicality of storage of flowers in sealed containers under refrigeration. A decade elapsed, however, before the method was developed for commercial use. Flowers stored in a very humid atmosphere with their stems not in water had a lower rate of physiological processes in comparison with flowers with stems in water. The florist industry has recently introduced prepackaged flowers. This combines refrigeration with dry storage in a humid atmosphere modified by the respiration of the flowers. The development work has been done by Laurie and associates at Ohio State University and Krone at Michigan State College. Usually the flowers are packed immediately after cutting, but in some cases a short period with stems in water is advised. The flowers are placed either in moisture- and gas-tight cellophane bags or in waxed boxes wrapped with cellophane, fastened securely to prevent bruising in transit, and the cellophane heat-sealed. The result is an attractive package which will stand handling and in which the flowers are well displayed. Studies at Ohio State University have shown that many kinds of flowers can be kept in sealed containers for 5–8 days at 40°–42° and after removal to room temperature have a normal life. Prepackaging offers possibilities for large-scale marketing of flowers at reduced costs.

In order to promote standardization, Post, of Cornell University, has recently proposed a flower-grading system based upon weight. This weight-grading system is rapidly being adopted by the floral industry.

The numerous innovations in recent decades have been worked out largely on an empirical basis. The advances in fundamental physiological knowledge of floral behavior, which may reasonably be expected, should contribute to further progress in this important, rapidly growing industry.

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RADAR DEVELOPMENTS IN GREAT BRITAIN

BRITISH radar, radio, and atomic scientists are working in a new field of research based on millimeter radio waves. This basic research is proving to be one of the most useful ways of investigating fundamental problems of the constitution of matter, and is likely to produce significant developments. Work on different aspects of this field is being carried on at the Clarendon Laboratory, Oxford, under the direction of Lord Cherwell, wartime scientific personal assistant to Winston Churchill; at Britain's Telecommunications Research Establishment; and at the Signals Research and Development Establishment.

A little more than one hundred years ago, the remarkable Michael Faraday, working in his laboratory in Britain's Royal Institution in Albemarle Street, London, discovered how light may be affected by magnetism. He was then fifty-four years of age. Some years later, at the age of seventy-one, he tried to discover whether a beam of light could be refracted by a magnetic field. He failed to detect any refraction, since the technique both of spectroscopes and of magnetic fields was insufficiently developed at that time. His last entry in his notebook was, "Not the slightest effect on the polarized or unpolarized ray was observed."

Thirty-five years later, Pieter Zeeman, in 1896, observed that the lines of the sodium spectrum broadened when the source of light was placed in the magnetic field of a powerful electromagnet. Using more powerful fields, he resolved single spectral lines into two lines. Clerk Maxwell's electromagnetic theory of light held that the system of electromagnetic waves must be emitted by vibrating electric systems, which today means atoms, protons, electrons. Thus the spectrum of an element is a window through which the single atoms in the group forming a molecule may be watched. From the data given by Zeeman's separation of spectral lines a new value for e/m, the ratio of the

electric charge to the mass of the electron, was obtained. This showed that the electric particles were identical with Sir J. J. Thomson's electron, whose existence he had proved from his cathode-ray tube experiments.

The Zeeman effect has played a great part in the development of our knowledge of atomic structure and of the energy levels of the electrons in their elliptical orbits around the atomic nucleus. So long as optical methods were used for examining the Zeeman effect on the spectra of elements, however, it could only be observed for those elements that could be excited to give out light when comparatively few were enclosed, as gaseous atoms or molecules, in an evacuated electric discharge tube. Thus the splitting of the atomic energy levels (the Zeeman effect) was restricted to the observation of comparatively few of the elements.

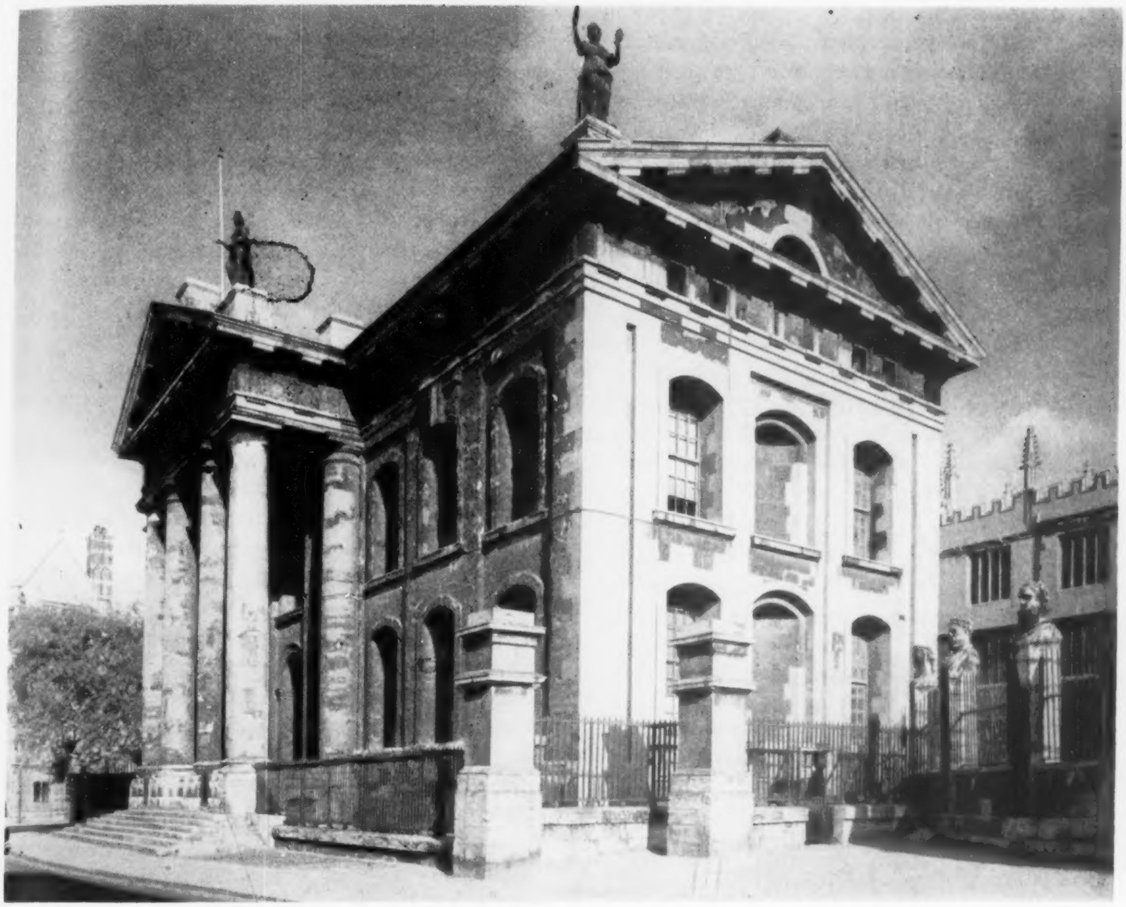
But radar has come to the rescue—the radar which was used during World War II to locate enemy aircraft and which enabled Britain's Fleet in the Mediterranean to come upon the Italian Fleet unobserved and destroy it. At the Clarendon Laboratory short-wave radar is being employed to allow the Zeeman effect to be observed in solids such as copper sulphate and thin metallic films. This is tied up with the absorption of very short radar waves (of millimeter wave length) by magnetic fields. Thus it has not only been shown directly by experiment that wireless waves are really streams of low-energy photons, but also that the window into the atom created by the Zeeman effect can be opened for solids as well as gases. It opens up a new and fruitful method for investigating the solid state, and already useful information has been obtained about the electromagnetic fields of force in crystalline solids. The interaction of the regularly spaced atoms in a crystalline solid broadens and displaces the absorption spectrum for a given substance. By measuring this effect, a picture of the manner in which the atoms of a crystal are influencing one another is obtained. Indeed, this particular method of using radar spectra affords one of the few ways by which the exchange forces in a compound may be studied in detail. Thus a further, most useful understanding of the total effect of the individual electric and magnetic fields of the atoms in a crystal is being obtained. These exchange forces are those which play so important a part in the chemical binding of elements to form a molecule.

A knowledge of the magnetic interaction of the atoms in a crystal is particularly important if such substances are to be made use of in reaching temperatures close to absolute zero. One of Faraday's great achievements was to discover the existence of paramagnetic substances. These are substances, which, if suspended between the poles of a magnet in a horizontal plane, will swing around until their longest axis is along the line connecting the poles of the magnet. In principle, it is always possible to cool a paramagnetic substance by first of all magnetizing it in an external field, insulating the substance so that it is thermally isolated, and then removing the electromagnet. The practical success of this method depends upon how quickly the entropy lost by the magnetized atoms can be abstracted from the lattice. Recent experiments show that this interchange can take place very quickly, even when the induced magnetism in the crystal is due to the very small magnetic moment of the atomic nucleus. The nucleus may be regarded as a rotating sphere, as is the earth, and therefore as possessing magnetic poles. These poles naturally enter into the magnetic forces in the crystal. The ultimate aim is to decrease the entropy to as low a value as possible, so that a close approach can be made to the absolute zero.

Experiments being carried on at the Clarendon Laboratory will, if successful, lead to the attainment of much lower temperatures than have ever been reached before. The approach will be made by steps getting within hundredths, thousandths, and perhaps within ten thousandths of a degree centigrade of absolute zero. The Clarendon is now installing a 1,000-horsepower generator to produce the power for the necessary magnetic fields for the experiment. But the most interesting point is that the necessary knowledge of the magnetic fields of force inside crystalline solids has been gained only by using very short radio waves instead of the "light" section of the electromagnetic spectrum.

During the past two years, much of the fundamental work on millimeter-wavelength radio waves was done at the Telecommunications Research Establishment, known everywhere as T.R.E., the world center of radar. This has meant the construction of minute klystrons, which have a power output of 10–20 milliwatts.

With the miniature version of the magnetron invented by Randall and Boot—whose mass production was worked out by one of Britain's principal electric companies—peak outputs of 10–20 kilowatts, with a pulse duration of one fifth of a microsecond, can be generated in the 8–9-millimeter wavelength section. These magnetrons are inconveniently small, however, and therefore small errors in construction are too noticeably magnified, so another source of millimeter radio waves is being fully investigated. This new source is the



The Clarendon Laboratory, Oxford, from Broad Street.

corrugated wave guide, which is a carefully constructed pipe, usually of rectangular cross section. Fitting across the guide are metal teeth, which are almost, in height and width, of the same dimensions as the cross section. Accurately machined cavities between the teeth proceed down the wave guide and act as equally spaced resonators, or klystrons in series. When the radio wave of the wave length that resonates with the cavities is transmitted down the wave guide containing the corrugations, it is slowed down; then if electrons, fired at their new velocity, are sent down the wave guide over the corrugations, they give some energy to the slowed-down waves and increase the power of the transmission.

It is this convenient source of millimeter waves that is making possible further interesting investigations into the behavior of atoms and molecules. The millimeter radio waves are in the small section of the electromagnetic spectrum, which merges into millimeter heat waves on one side and into the centimeter-wavelength radio waves on the other. Thus they have atomic and molecular effect rather similar to heat waves. For example, when millimeter waves are transmitted into the atmosphere, a series of absorption bands is noticed. At 1.25 centimeters wave length the absorption is very marked. The energy of the transmitted wave has been quickly used up in energizing the water-vapor molecules that are present. At a wave length of 5 millimeters, the oxygen molecules absorb; but between 8 and 9 millimeters there is a window in this atmospheric "wall against radar," and millimeter waves may be transmitted with little absorption.

The useful information about molecules is obtained from what is known as the "critical frequency." This is, in effect, the frequency which will be absorbed under certain standard conditions. The mass of atom or molecule, together with various magnetic and electric forces, will allow only a maximum amount of energy to be absorbed, which with the water molecule was, as has been seen, represented by the wave length of 1.25 centimeters, and represents photons of a certain low energy.

With gases the position is further complicated, since the waves cause not only vibrations but also spin the molecule. With ammonia gas, which consists of three hydrogen atoms arranged at the corners of the triangular base of a pyramid, with the nitrogen atom at the apex, the radio-wave energy is used up largely in moving the nitrogen atom from one side of the base plane to the other.

A practical application of absorption is in meteorology. Since the amount of water vapor in the atmosphere has a considerable effect on the dielectric constant of air, a measure of the amount of absorption in a given length of wave guide filled with the moist air, when compared with a similar guide filled with dry air, gives a very accurate determination of humidity.

Since this work deals with wave lengths on the infrared fringe, experiments to refract millimeter waves as light is refracted by glass and other transparent substances have naturally been made. Solid lenses of glass, "Perspex," or other dielectrics, or nonconductors of electricity, must, however, be of very large diameter, and therefore very heavy. A new technique eliminates this difficulty. Instead of, say, a convex lens of solid glass, flat plates of aluminum are stacked apart in parallel planes, as in a radio tuning condensor, but with their exposed edges curved so that, altogether, they form the skeleton of a convex lens. Thus, in the future, it appears that millimeter waves will be guided by a system of wave guides and lenses. This will eliminate much of the trouble where the flanges of two wave guides meet.

Manufacturing limits must be so fine that the slightest unevenness must be avoided. Indeed, the necessity for working with miniature equipment, which allows only very small tolerances in its manufacture, has resulted in a search for new systems of transmission, generation, and detection of millimeter radio waves.

Millimeter radio waves have captured the imagination of Britain's radar, radio, and atomic scientists and are on the way to becoming one of the most useful weapons in the attack on the constitution of matter. It is remarkable to realize that this new field of basic research began when, in 1924, Sir Edward Appleton proved for the first time, experimentally, the existence of the Heavyside-Kennelly Layer and of his own Appleton Layer by using the reflective property of long-wave electromagnetic or radio waves. Then, in 1935, came the early experiments, in Britain, on systems to locate and detect aircraft. From detecting vast agglomerations of countless billions of atoms called aircraft, the system has been refined to determining molecules and to allow peering into the inside of crystals, determining facts that are outside the possibilities of long-established X-ray crystallography, founded some forty years ago by Sir William Bragg.

Now, it seems, resonating gas molecules may be useful, in turn, in creating such fine control of the frequency of transmitted radio waves that today's vibrating quartz-crystal methods may be regarded as providing only a rough control. This is likely to come from the work being done at the Signals Research and Development Establishment, near Bournemouth, Hampshire, England. Gases are being vibrated by resonance between the poles of very strong magnets. This work began only in the spring of 1948, and is of such a fundamental nature that it will be some little time before full results are available.

The first-class work that is proceeding, and that has been done, in Britain since World War II in the wide field of radar has already astonished visiting scientists from other countries. And yet it is but the logical development, through generations, of the work of those two great geniuses of a century ago, Michael Faraday and James Clerk Maxwell.

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METHODS OF MEASURING FLAVOR QUALITY IN FOOD PRODUCTS

THE measurement of the quality of flavor in food products is complex, since it involves subjective responses. Three distinct senses—taste, smell, and feeling—are involved in the tasting of foods. When food is taken into the mouth, the taste buds, located chiefly on the tongue, are stimulated; if the food contains volatile odors, the odor detection area located high in the nasal cavity immediately below the eyes quickly perceives the sensation, and the sense of feeling detects differences in texture of foods and cooling, burning, puckery, and stinging sensations caused by some products. It is common knowledge that the true sense of taste discerns well the flavor of substances such as sugar, salt, lactic acid, and quinine. Such products as fruit and coffee, however, depend more on the sense of odor than true taste. Texture is closely associated with flavor, and undesirable

texture is detrimental to the flavor quality of foods. Texture may influence flavor in another way. A thin liquid of strong taste will seem much weaker in flavor if a thickening agent is added; apparently the increase in thickness mechanically affects flavor perception. Although food tasters are conscious of the distinct senses involved in flavor evaluation, at the time of comparing samples they are more concerned with the quality of the flavor than the responses involved.

Fine flavor is a major goal of all attempts to develop new food products. Lack of dependable objective methods for evaluating flavors has led to the wide use of systematic tasting by experienced personnel, using the so-called organoleptic tests. With the development of new and improved foods, the public is becoming more discriminating in the selection of foods on the basis of flavor. As a consequence, food processors, experiment stations, and other public and private institutions concerned with food quality are placing a great deal of emphasis on the development of flavor evaluation procedures. In recent years, the problem has been extensively studied, and many articles concerning the organoleptic evaluation of foods have been published. In many instances in the past, too much reliability has been placed on the judgment of one, two, or three persons relative to the flavor quality of products.

Since tasting for flavor requires extreme concentration, it is necessary to have a suitable room to carry out the tests. The tasters should be able to sit down and have the samples placed before them on a table that is at least partially partitioned from the person next to them. The room should be free from odors and outside disturbances, and the tasters should be comfortable and relaxed. The three distinct senses telegraph to the brain simultaneously the perception of any particular flavor, and one may fail to get the message, or may get it incorrectly, without concentration on the job in hand. Decisions are very easily influenced by comments of others. The room should be well enough lighted to make color comparisons of some products; in other instances differences in color need to be covered up so that they will not influence flavor judgments. Red darkroom bulbs are satisfactory for this purpose.

The number of samples that can be tested without fatigue, the temperature of samples, and time of making tests must all be given consideration. Fairly large numbers of samples of products such as milk, coffee, and tea can be tasted by trained tasters during a day, without excessive taste fatigue; of course, a rest interval is necessary between each set of samples to allow the taste buds to recuperate. On the other hand, after tasting a few samples of jellies and jams or strong-flavored foods, differences in flavor very quickly become difficult to distinguish.

No definite conclusions have been drawn as to the most desirable temperatures for the organoleptic examination of products. There is a general feeling that the product should be examined at the temperature at which it is normally served. There are obvious exceptions to this rule, especially where the tests involve foods that are consumed at relatively extreme temperatures. Bengtsson and Helm[1] state that the optimum temperature for the perception of taste is generally considered to be about 20° C or somewhat higher and that, when 50° C is reached, the gustatory nerves cease to function.

Midforenoon and midafternoon are generally considered to be very satisfactory times for conducting taste tests.

The selection, methods for handling, processing, packaging, and storage of foods in relation to quality of their flavor are problems which are also of great concern to food processors and research laboratories. The flavor evaluation panel is an analytical tool to guide them in their research in the development of foods with the best flavor qualities. Careless use of the tool may result in useless or misleading results. If a systematic procedure is used, however, practical results may be obtained. For most organoleptic tests, a numerical scale should be set up for evaluating the quality of a product. It is a guide for the tasters scoring products and can be used to advantage in the statistical analysis of the results.

Plank[2] discusses types of scales used and believes that it is important that numerical grades for any single food property should be proportional to the quality expressed in descriptive terms. For example, a scale of 1 to 10 has been found to be very satisfactory. A sample rated excellent is given a score of 10; very good, 9; good, 8; slightly good, 7; fair, 6; fair minus, 5; slightly poor, 4; poor, 3; very poor, 2; and extremely poor, 1.

People in many walks of life can become good flavor testers. However, they must be selected on the basis of their ability to differentiate flavors and to repeat flavor judgments, and it is important that they have good flavor memories. Not all tasters do well on all products, so it is advisable, if possible, to make a differential grouping of tasters to use on products on which they do the best work. Since people do not react the same to foods from day to day, it is unwise to depend on

the judgment of two or three persons. It is most important that good tasters have the opportunity to gain experience by frequent participation in the flavor evaluation of specific foods.

If a large number of individuals are available in an organization, it is advisable to make use of as many of them as can be conveniently handled. Careful written records of all tests should be kept. A triple comparison method might be used as a good systematic procedure whereby two identical samples of either the unknown or control are included in the series, and one additional sample—the problem here being to select the one sample different from the other two. Such a test is very helpful in the selection of tasters and should be repeated several times as a thorough check on their ability. With this test, fifteen to twenty persons with the highest percentage of correct answers can be selected for a specific test at hand. Obviously, the scoring is all done without the tasters knowing what the individual samples are; they should know the general purpose of the test, however. For example, it may be desired to determine the effect of storage times and temperature on a product, or temperature and period of heating, or variations in sweetness.

The following test will illustrate a triple comparison procedure, used by the Food Science and Technology Division of the New York State Experiment Station, to evaluate flavor changes in good-quality commercial strawberry preserves resulting from times and temperatures of storage.

1. Control stored at 34° F., for 14 weeks.
2. Stored at 60° F., for 14 weeks.
3. Stored at 100° F., for 14 weeks.

In one test each person making the comparison was given two samples of the control and one sample of the strawberry preserves stored at 100° F. In another test, each person was given one sample of the control and two samples of the preserves stored at 60° F. for fourteen weeks. Each sample was designated by a series of letters or a series of combinations of numbers and letters as a code. In this way those working next to each other in a room would have the same sample with different code numbers, which would discourage a comparison with their neighbors. A summary of the scores taken from the score sheets is given in Table 1.

The results of the scoring for this first comparison indicate that there is a significant difference in flavor between the control and the sample stored fourteen weeks at 100° F. Likewise, the scores show a 100 percent preference for the control over the sample stored fourteen weeks at 100° F. Only scorer N indicated a significant difference in the control samples by the score of 9 and 7 for the same sample; none of the others varied more than 1 point difference for the control samples, and nine of the others gave the control samples the same score.

The sample stored at 100° F. for fourteen weeks was considerably darker in color than the control and had developed a cooked flavor but no objectionable off-flavor. The scoring was done in a darkened room to cover up the difference in color of the samples.

TABLE 1

FLAVOR SCORES OF STRAWBERRY PRESERVES

Panel	Comparison I			Comparison II		
	Control	Control	14 weeks at 100° F.	Control	14 weeks at 60° F.	14 weeks at 60° F.
A	7	8	4	8	7	4
B	9	9	6	8	9	9
C	9	9	5	10	10	9
D	9	10	4	8	9	5
E	9	9	8	8	9	8
F	8	9	4	8	9	6
G	9	9	4	8	6	6
H	7	8	5	9	8	7
I	9	9	7	9	9	9
J	10	10	9	10	10	10
K	10	10	4	9	10	7
L	10	10	6	8	10	10
M	9	8	4	8	6	6
N	9	7	3	–	–	–
O	9	9	5	9	9	9
Total	133	134	78	120	121	105
Average	8.9	8.9	5.2	8.6	8.6	7.5

The results of the scores on the second test do not indicate a significant difference between the control and the samples stored at 60° F. for fourteen weeks. Scorers A, D, F, and K indicated a significant difference by their scores of two identical samples. They were either guessing, or their flavor judgment was off for that test. Throwing out these sets of scores, the average scores for the samples would be 8.7, 8.6, and 8.3, respectively. Only two of the fourteen scorers indicated a significant difference between the control and the fourteen-week samples. There might have been a slight difference in flavor of the control and stored sample, but the difference was not significant or great enough for the scorers to detect.

A paired comparison procedure used in obtaining a preferential rating of several lots of a product gives very good results. In this case the preference of one product over another is not in-

dicated by a score. The samples of the product are placed before the observers in a series of pairs and they are requested to state their preference. When no preference is indicated, the reply is not used. Preferably only one comparison is made at a given interval. The samples are given code numbers, and identity of the samples is unknown to those scoring them. If it is desired to rank in order of preference four materials designated for the purpose of illustration as A, B, C, D, a series of six comparisons is made, namely, A *vs.* B, A *vs.* C, A *vs.* D, B *vs.* C, B *vs.* D, and C *vs.* D.

On the basis of the information gained from the preference of persons by this type of study, it is possible to rank them in order. Since such a group of persons is uncalibrated and its reliability unknown, it is necessary to assume that the group follows about the same order as in normal population groups; that is, when the difference between quality of items may be small, 50 percent of the judgments will be found to be unreliable. It is therefore necessary to subject the data to a certain amount of analysis to determine its reliability. The chief objection to this type of test is the time-consuming element.

In many instances a panel of six to twelve persons is used for flavor comparisons of series of samples. It should be pointed out that in these panels people selected for reliable judgments should be calibrated by hundreds of examinations that are a matter of formal written record. A judge may be required to have an average deviation of not more than 1 point from the average scores of the group, and a standard may be set for his ability to repeat judgments on duplicate samples. A numerical scale as previously mentioned is used for this panel method. A beginner can gain experience by working with a group of trained observers.

Wherever possible in the scoring of a product, especially with persons lacking experience, it is desirable to select a very good sample, a fair sample, and a poor sample of the product for reference standards. These samples should be scored by the panel, and the averages of the scores for each sample will designate the score of the sample for reference purposes.

The chief concern in this type of work is the significance of the results. The procedure used, the number and efficiency of the tasters, and the number of tests on a specific product influence this significance; however, the application of statistical analysis to the results is the measure of their significance.

Consumer-acceptance tests are another story in themselves. Many food laboratories interested in developing processing techniques to improve the quality of a product usually do not obtain a large-scale consumer reaction to the product in question even if their interest is obviously in the consumer acceptance of the product. Many commercial firms use panels selected from their own employees to screen newly developed products, and those deemed sufficiently good are subjected to a consumer-acceptance test before they are placed on the market. Some companies set up their own acceptance tests, and other companies use professional agencies whose business it is to collect information on an item. Even a good-sized flavor-evaluation panel cannot be selected which will be representative of consumer acceptance, because such factors as food habits, race, section of country, age, and economic status affect acceptance of foods. It is for this reason that many companies wish to obtain the reaction of their consumers prior to placing new and improved types of products on the market.

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BOOK REVIEWS

OF THE HUMAN MIND

Studies in Analytical Psychology. Gerhard Adler. 250 pp. Illus. $4.00. Norton. New York.

THIS book has emerged from six lectures on analytical psychology presented by the author over a period of fifteen years at various scientific gatherings in London. The lectures have been reworked, expanded, and sequentially arranged so as to provide an effective vantage point for viewing the larger facets and implications of Jungian thought. It is not a systematic presentation of doctrine and theory, but rather a synthesis of important aspects of it, as seen, particularly, in clinical practice.

The psychology of C. G. Jung stresses the constructive role of the unconscious in personality integration. For him and his followers, the unconscious is the vehicle of the wisdom, needs, and energies deriving from countless eras of ancestral experience. It is the potent and creative layer of the psyche, the "matrix" of the conscious mind. This psychology has undoubtedly a greater appeal for the nonprofessional reader than have other varieties of medical psychology. Perhaps it recommends itself especially through its positive orientation and concepts which are not at war with religious philosophy. It also strives for flexibility in dealing with clinical problems, viewing each patient as unique, each individual as "an experiment of ever-changing life and an attempt at a new solution or new adaptation."

Dr. Adler makes an interesting study of the techniques of Jungian psychology as compared with Freudian and Adlerian schools. He discusses dreams as manifestations of the archetypes of the collective unconscious; cycles of life as related to the ego and different psychological problems; the therapeutic use of unconscious forces; the compatibility of religious and analytical points of view; and, finally, the meaning of Jung's work to modern man. As the protagonist of a theoretical point of view in medical psychology—a fascinating but highly controversial one—the author has done an excellent job. His book is readable as well as informative.

Readings in the Clinical Method in Psychology. Robert I. Watson, Ed. xi + 740 pp. $4.50. Harper. New York.

WELL-SELECTED papers, fifty in number, published by leaders in the field of clinical psychology over the past twelve years, provide a comprehensive coverage of the status of applied psychology. The editor has classed the contributions into four groups, for each of which he has written a chapter critically reviewing broad developments or pertinent literature omitted from the readings. The first group is concerned with the clinical method itself; the second, with the functions of the clinical psychologist; the third, with diagnostic methods; and the fourth, with methods of treatment.

Clinical psychology encompasses broad areas of practical interest. In many arenas of modern life, in industry, schools, courts, prisons, institutions, military set-up, in many social settings, and chronological groups it performs the functions of selection, guidance, interviewing, and counseling, delving carefully into problems of normal and abnormal behavior. As a discipline allied with psychiatry, its most familiar function is, of course, psychometrics. The psychiatrist, who has firsthand knowledge of its value in this respect, as an adjuvant to diagnosis with all this implies for the future handling of the patient, has been slow to recognize the therapeutic role which the clinically trained psychologist might play. The Veterans Administration has recognized it, however, and there is a definite movement, in many quarters, toward assigning the psychologist broader functions. It is becoming increasingly obvious that the psychologist can make a useful contribution to the large borderline group between those we consider normal people and those frankly suffering from mental disease.

Clinical psychology bears heavy responsibilities, both in keeping high its standards for training and practice and in allocating its practitioners to the areas where they may specialize to best advantage. It is encouraging that a certifying professional body has recently been organized by the American Psychological Association to pass upon professional fitness. This will help keep at a distance those charlatans and incompetents who have been a menace to scientific psychology and psychiatry as well.

Watson's *Readings in the Clinical Method in Psychology* affords an excellent perspective of accomplishments and problems of clinical psychology. It is an indispensable reference work in the field.

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Basic Principles of Psychoanalysis. A. A. Brill. xv + 298 pp. $3.45. Doubleday. New York.

DR. A. A. BRILL may fairly be credited with having introduced psychoanalysis to America. He translated the works of Professor Freud into English, and was tireless in explaining them to medical and lay audiences by lecture and pen. He was a respected leader in the rapidly growing psychoanalytic society until his death at the age of seventy-four.

This book again undertakes to present the basic principles of Freud in a manner comprehensible to

the layman. Dr. Brill's style is sprightly. Every page is enriched with illustrative anecdotes from his enormous experience. He shows how the unconscious operates in the daily life of normal people, as well as in the queer behavior of the mentally ill. He demonstrates that none of our behavior is "senseless," but its meaning may be disguised because the underlying purpose is not one we can admit even to ourselves. He is especially successful in relating the modes of thought characteristic of early childhood to those observed in the dream, in slips of the tongue, in forgetting and other unconsidered phenomena of everyday life, in choice of vocation, in artistic productions, and in the pathological symptom.

The defect of the book is that it is already "dated." Even as an exposition of Freud, it suffers from the omission of the professor's later work on the ego and superego—that is, his more careful analysis of the forces which oppose direct expression of the primitive sexual "wish." Dr. Brill attempts theoretically to broaden the concept of sexuality to "love," but his concrete illustrations tend to fall back upon sexuality in the old-fashioned sense of mating, with too little consideration of oral and anal components, or the primitive fear of loss of love. The brilliant developments of later Freudian doctrine and contemporary psychoanalysis in the area of character formation and the intricate dynamics of "ego defenses" are almost entirely ignored.

The chapter on major mental disease, the psychoses, is dangerously obsolete. At a time when the label "schizophrenia" is being widely applied to persons previously considered neurotic (who often get along quite well in life), Dr. Brill describes all too vividly the horrid course of the disease as known to psychiatrists twenty years ago. The patient, family, employers, and teachers who happen to encounter this new use of the diagnostic label may be needlessly frightened by a book published in 1949 by a respected authority. At a time when shock treatment is familiar to nearly everyone through the public press, it is strange to find no mention of it except a personal anecdote about a patient who recovered dramatically during an incidental operation, only to relapse completely three weeks later. Psychoanalytic interpretations of the psychoses are not included. One could wish that the editor of this posthumous book had had the courage to delete this section altogether.

It is hard to recommend Dr. Brill's book as an authoritative treatment of present trends in psychoanalysis and psychiatry. The wealth of clinical material makes it valuable reading for any person, lay or professional, with perspective to see it as a simplified exposition of Freud's earlier work, enriched by the personal observations of an astute doctor.

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HISTORY SOUTH OF THE EQUATOR

Paraguay. Harris Gaylord Warren. xii + 393 pp. Illus. $5.00. University of Oklahoma Press. Norman.

MR. WARREN'S book, although it is only a brief summary of the rich and little-known history of the small and gallant nation of Paraguay, is more noteworthy than any other publication I have read on the subject. The author has spared no effort to compile information and to delve deeply into serious research in order to bring forth an intelligent and comprehensive synthesis of the most interesting events and personalities in Paraguayan history.

Written in an appealing and open-minded fashion, it analyzes the period of Paraguay's history from the time of the bloody conquistadores, through the colonial days, the tyranny of Francia and Lopez, to the present era.

Among the many interesting passages of the book, the tales of the Guarani Indians are especially captivating. The Guaranis, an extinct tribe, left nothing of their civilization but their language, which survived the conquest of the Spaniards, who, with refined cruelty, tried to "humanize" the Indians. Guarani is still the language that pulsates in the heart of every Paraguayan today. One hears it in the streets, in the market places, and in the homes of rich and poor alike. Many books and pamphlets were written in Guarani; the Bible was even translated into that language by the Jesuits. And yet there is not a single school in Paraguay that teaches it; it is learned in the most peculiar and unorthodox manner, from servants, from the peasants, and from the farmers who come to the cities to sell the products of their land.

Paraguay, economically strangled by its neighbors, has been striving desperately to attain economic independence since the days of Gaspar Rodríguez de Francia—one of the most notable personalities in Latin-American history, as described by Thomas Carlyle in one of his essays.

Francisco Solano Lopez, who waged a war against the combined forces of Argentina, Brazil, and Uruguay that practically annihilated little Paraguay, represents the fight to the death against the imperialistic encroachment of Brazil and Argentina, whose armies, under the guise of liberators, invaded the country, annexed a good portion of the land, and carried away with them the loot of victory.

The turbulent legacy that Paraguay inherited from the Spaniards, the Guarani Indians, Francia, and Solano Lopez is still very much in evidence in modern Paraguay, as indicated by the continuous internal upheavals which, combined with the nation's poverty, continually retard its recovery.

Mr. Warren deserves the highest praise for his honest attempt to bring together in book form the loose and much-disputed history of Paraguay. It provides important material to fill the gap in the relations

of the nations of the Western Hemisphere, their people, their sentiments, and, most important of all, it encourages mutual understanding through better knowledge and appreciation of each other's problems, past and present.

CARLOS GARCIA

Pan American Union
Washington, D. C.

WAVE OF THE FUTURE

Engineering the New Age. John J. O'Neill. 320 pp. $3.50. Ives Washburn. New York.

SINCE 1926 Mr. O'Neill has been interpreting the progress of scientific research to the readers of the *Daily Eagle* and *Herald Tribune*. In so doing he has had to keep in touch with the investigations undertaken by scientists in all fields of human endeavor. The present volume quite naturally reflects the myriad contributions these studies have brought to the daily needs, comfort, and fundamental understanding of man. The author accepts Gano Dunn's definition of engineering as "the art of the economic application of science to social purposes." Engineering would thus pretty well encompass human life in all its aspects, since among the accredited curricula in departments of engineering mention is made of such branches as aeronautical, agricultural, architectural, chemical, civil, electrical, industrial, mechanical, metallurgical, mining, sanitary, and many others. Doctors and sanitary officials are classed as engineers, applying the results of scientific research to the problems of health and disease.

In the author's imagination engineers should be, and in the future will be, in charge of human affairs and progress, directing man's efforts toward the control of his environment. Mr. O'Neill envisions a time when it will "make no difference where the Great Lakes are, in which direction the Mississippi flows or whether the Tennessee Valley dams are full or empty." For man shall make whatever weather he chooses, rain, shine, cold, or warm. "Farms will be factories in buildings independent of sunshine, rain or soil." Land may then be devoted to other purposes, for playground or scenic satisfaction. An enzyme may be discovered or synthesized which, in the circulating blood, will create all the amino acids we need, thus releasing us from dependence on animal food.

We might by chain atomic energy raise up new mountain ranges within a year's time or tilt the surface of the country differently at will, making the Mississippi run north if we so desired, or locating the lakes more conveniently for the economy or aesthetic joy of the people.

All human activities will be guided by engineers who "chart and control social strains and stresses in a community without regard to any set of political principles or party interests." The future welfare of mankind is to be laid on a firm and stable keel by a general planning committee who will blueprint the lines of development for 10,000 years in advance.

All existing cities will be torn down and rebuilt according to a plan for the whole country, relocating them rationally instead of in the present haphazard manner. Quite understandably this view is focused on the indefinitely distant future when the "multiman" shall have arrived.

E. V. WILCOX

Washington, D. C.

ALL ABOUT SEA URCHINS

A Monograph of the Echinoidea. Th. Mortensen. Vol. IV. 1: *Holectypoida, Cassiduloida*, 363 pp. Illus. 2: *Clypeastroida*, 471 pp. Atlas, with plates. C. A. Reitzel. Copenhagen.

WITH the appearance of this double volume, one of the most Gargantuan of monographs is nearing completion. Only one more volume remains to be published, and it is to be hoped that it will come out during this year, so that the more than eighty-year-old author will be able to look at almost two feet of shelves of a completed supermonograph, in which for once the first-rate typography, the magnificent plates, the detailed text figures, etc., are equalled by a first-rate piece of scientific work. Outside of libraries, of course, very few persons will own this expensive opus, but there is no doubt that for years to come it will be the standard work which every student of sea urchins will consult. Extracts, as well as copies of figures, will find their way into smaller papers, which is perhaps the greatest satisfaction an author can have.

The monograph was begun in 1935—the final work of a hard-working man who had been a devoted student of echinoderms since the end of the last century. His age—around sixty-five—probably seemed just right to him, for although others begin to think of retiring at that age, he probably felt that he had just reached a point where he would not make too rash and youthful conclusions. The invasion of Denmark made comparatively little change in his work, except that he was cut off from examining material in other museums, particularly the unexcelled collections in the United States—in the U. S. National Museum and in the Museum of Comparative Zoology—as well as those in the British Museum, which were hidden away during the blitz. But in the same moment the armistice came, material was again sent across the sea, and he was able to put his final conclusions into the manuscript before it went to the printer.

In the first volume he treated the Regularia, fossil and Recent, and in the present volumes he has dealt similarly with the greater part of the Irregularia—that most fascinating division of sea urchins in which the members have abandoned their almost perfect symmetry and made an attempt or, rather, several independent attempts, to achieve a bilateral symmetry. At the same time, some have discarded their unique

dental apparatus, so well known to all students of elementary biology, namely, the lantern of Aristotle, with its five powerful rodent teeth, which enables its owner to chew up the most leathery kelp and even excavate holes in the rocks wherein he can live. It is also in this unorthodox group that one finds the greatest aberrations of the tube feet, from the simple suction disk of leaflike structures that function as gills, or handlike developments that are able to gather up minute edible particles and stuff them into the toothless mouth. In no other group of echinoderms are the evolutionary trends so rampant, and with the fossil evidence on hand, one is here able to piece the sequence together almost as perfectly as in many of the vertebrates.

The author has worked with these animals for almost sixty years, with an enormous amount of field work and embryological studies besides his museum work. Here in this final study he has transgressed into the field of paleontology and included all the known fossil forms. It was Robert T. Jackson's idea that a paleontologist should be familiar with the living forms in order to interpret the more incomplete fossil data, and the author of the *Phylogeny of the Echini* would undoubtedly be pleased to see the manner in which his old friend, with his extensive knowledge of the living forms, has tackled the fossil species.

The fourth volume follows the pattern laid down in the first volumes, and there is the same evenness in the treatment from beginning to end which makes it such a pleasure to use the work. Extensive lists of synonyms are supplied, although it seems almost humanly impossible that the author singlehanded should have been able to round up every one of them. Clear diagnoses are given, and keys, so that any person with a fundamental knowledge of the morphology of the sea urchins will be able to find his way though the entire work and identify whatever sea urchin, living or fossil, he has before him. There are excellent descriptions, detailed information about distribution, critical discussion of nomenclature, and extensive lists of literature. Those who are accustomed to the American method of indicating where the type is deposited, and how many specimens the author has examined, may deplore the lack of such details, but there is no doubt that the presence of such data would have increased the bulk of the volumes and possibly detracted somewhat from the flowing ease with which the account runs along. Extremely valuable is the abundance of text figures, mostly original, showing the arrangement, the structure of the apical field, cross sections of spines, etc., which accompany the text and supplement the first-rate photographs of the plates. After having examined the volumes, one is still unable to understand how a single man has been able to make so gigantic a contribution, even when in his later years he was relieved of all routine duties and had the wholehearted support of all the workers on echinoderms in the world (not a very large group, it must be admitted). With the many and often well-justified criticisms that have been directed against systematic zoology, it is a satisfaction here to be able to point out a whole group of animals that have been studied as they ought to be, and where a solid foundation has been laid from which one can begin to explore these animals from other angles.

Last but not least, one feels a deep gratitude toward the Danish government and the Carlsberg Foundation, which have enabled the author to carry out his great work. From start to finish he has been freed from worries of all kinds, and in spite of war and occupation, paper shortages, and other difficulties, he has been able to feel that the high standard of printing and reproduction of plates would not be abandoned, that he would never be let down in spite of economic difficulties. Both the author and his country have every reason to be proud of each other.

ELISABETH DEICHMANN
Museum of Comparative Zoology
Cambridge, Massachusetts

HIMALAYAN BOTANY

The Valley of Flowers. Frank S. Smythe. 325 pp. Illus. $5.00. Norton. New York.

A REVIEW appearing in a scientific publication must begin with the statement that this book's title and the claim made on its jacket that the volume is perhaps the best on the subject of Himalayan botany are rather misleading. A good part of the book is dedicated to a cataloguing of plants seen or collected by the author during his stay in the remarkable valley about which he writes. But Smythe's botanizing was of the incidental, enjoyable kind, the kind that makes the world of plants and flowers sometimes mean a great deal more to the amateur than to the botanist, who must concern himself with problems of form, function, and relationships. The author's deep appreciation of the beauty of plant material and his deft use of words in describing their beauties add a delightful dressing to his book. They make most pleasant reading of a mountain-climbing tale that might otherwise be of interest only to mountaineers. For most of us there is fascination in words about faraway places. There are thrills in the details of such adventures as Smythe's mountain-climbing expedition, and there is real lure in such excellent, and in the midst of a hot Texas summer perhaps I may add cooling, photographs as he has included in his volume.

More than anything I have seen in a long time, this book provides an opportunity to get away from it all for a few hours. It is diversionary reading at its best.

W. GORDON WHALEY
The Botanical Laboratories
The University of Texas
Austin

BASIC GUIDE FOR LIVING

Biology for Everyone. W. Gordon Whaley. xi + 374 pp. $2.79. Illus. Garden City Publishing Co. Garden City, N. Y.

IN AN exceedingly interesting book, characterized by lucidity of exposition and deft continuity in the presentation of the subject matter, the author gives a well-balanced outline of biology. The chapters fall into three general groupings: six devoted to what used to be called "general physiology;" five on kinds of plants and animals, speciation, evolution, and the origin of life on this earth; and six on biosis—ecology, reproduction and sex, inheritance, plant and animal health. There is a résumé chapter stressing plant and animal science as it affects the individual.

An author presenting the elements of a branch of science could disclaim intent of writing for his colleagues and plead that dogmatism of statement should be charged to a desire to avoid confusing the beginner. But in his preface Whaley announces his intention to "introduce the reader to the science of Biology as a whole. . . . This wealth of knowledge is presented here for those who have not taken courses in the subject and for those who wish to turn to it for review in the light of recent advances." Lest this be taken as the opening gambit for slashing criticism or devastating comment, the reviewer hastens to state that in his opinion the author surprisingly well achieves his purpose and will please both categories of readers.

With profit, we may explore the technique that enables the author to cover the full gamut of biology in a manner acceptable to the trained scientist and at the same time to produce a book entirely intelligible to a high-school student who commands a vocabulary slightly beyond basic English. The author is precise in statement, uses technical terminology as necessary, does not write down to the reader, and eschews Sunday-supplement style. The key seems to be the efficient organization of the subject matter, and the omission of extraneous details, or side excursions, no matter how intriguing these may be to the specialist. The author knows what he wants to say and says it. The reader will wish there were more, and that's the great art of both letter- and book-writing. Consistently, topics are presented according to their historic development, each major contribution to science being tagged with the name of the discoverer. Thus each chapter, after an orienting series of questions and an introductory statement, shows how a particular phase of biology developed, what the building stones were, and who fashioned them. This scheme of presentation not only outlines biology but constantly brings to the fore its dynamic nature, no phase being presented as a closed episode. Much of the charm of the work and of its appeal stems from this portrayal of science as a living, growing thing, always on the threshold of new advances.

Science also has its heroes. The author heads each chapter with the names of those who have made fundamental discoveries. In the appendix, under "Biographical Notes," a complete roster of the scientists is given, the life span shown, and the chief contribution of each epitomized. Usually there is no formal citation of publications, exceptions being books that have had far-reaching effects or have been, in their day, highly controversial.

Probably no one would query the scientists included, but each might note omissions. Firsts in discovery are assigned. These conform well with current acceptance, but of course such assignment would receive the customary revision or qualification by the specialist. No scientific worker is an island. But the specialist should not complain because individual discoveries appear in the book as the building stones of our knowledge, whereas general contributions, even the founding of entire fields of biological science, do not fit into the presentation pattern and may not be registered.

The text is effectively illustrated with line drawings by the author's wife, Clare Y. Whaley. These very definitely contribute to the presentation of the subject matter. Their simplicity and originality make them a welcome relief from the stand-by illustrations that have passed from one text to another. Possibly some indication of the relative size of the object or part illustrated would help the uninitiated.

The book gives the core material for a complete biology course. It may find a place as a beginner's textbook. The teacher, by laboratory exercises and discussion, would need to round out the condensed, almost summary, statements. There seems to be a tendency for beginner's books to be encyclopedic and to bristle with footnotes and references. Possibly such books are too formidable and their effect discouraging. Here is a book that a student could and would come to know, and it would build for him an apperceptive mass requisite for adjustment to, and appreciation of, his natural environment.

The final paragraphs of the book deal with man's place in nature. They constitute an admirable statement of the biologist's creed. As Whaley sees it, biology

> provides the basic guide for living. Man's evolution has carried him far. He is much more than an animal, and there is much in his life which is not shared by other organisms, is not translatable into the terms of biology and the other sciences. However, as man is but one of the countless living organisms inhabiting the earth, the fundamental requirement is that he conform to the organic pattern. Only thus can man respect his limitations and realize his potentialities.

G. H. Coons

Bureau of Plant Industry, Soils and Agricultural Engineering
USDA
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A NATURALIST IN THE TROPICS

High Jungle. William Beebe. 379 pp. Illus. $4.50. Duell, Sloan & Pearce. New York.

AT THE death of the Venezuelan dictator Juan Vicente Gómez, in 1935, work was halted on an extraordinary structure nicknamed *Rancho Grande,* situated at the mountain pass of Portachuelo above Maracay. This grandiose but unfinished building, part of which has been outfitted for laboratories by the Creole Petroleum Corporation, stands at the center of a vast reserve of unspoiled cloud forest. Dr. Beebe's most recent book recounts, in rambling style, the "lighter aspects" of zoological field work conducted there during parts of the years 1945, 1946, and 1948.

Fortunate indeed must be the naturalist who finds himself stationed at a place so integrally a part of the primitive forest. We learn that marsupial frogs and even fers-de-lance inhabited its rooms, blue-and-white swallows bred in its crevices, and in its neighborhood one might hope to see almost any bird or mammal of the coastal Andes.

As the author himself has written in his preface, this volume attempts to give only the more inconsequential phases of his work in Venezuela. The book is directed to the reader whose interest in natural history is nontechnical and who must usually visit jungles from an armchair. The reader with a more technical interest may be at times exasperated by having his curiosity aroused by some diverting discussion of the strange ways of bird or butterfly, which is not carried on to a satisfactory conclusion. For him, however, there are two appendices, one giving the scientific names for creatures mentioned in the text in vernacular, the other listing the published scientific papers that have resulted from Beebe's Venezuelan expeditions. In any case, it may safely be said that no naturalist who has experienced a taste of life in the New World tropics is likely to lay the book down without twinges of envy and nostalgia.

The beautiful photographs and the excellent typography add much to the volume's interest, if anything more were needed than the author's infectious enthusiasm for his subject, whether describing the family life of bat falcons, the fauna of a forest pool, or the effects of unprecedented rainfall upon the Andean slopes.

H. G. DEIGNAN

Smithsonian Institution
Washington, D. C.

BRIEFLY REVIEWED

Carl Alsberg—Scientist at Large. Joseph S. Davis, Ed. xi + 182 pp. Illus. $2.00. Stanford Univ. Press. Stanford, Calif.

THIS fine volume is a collection of five biographical essays upon the life of Carl Alsberg, together with three of Alsberg's own papers and a classified bibliography of his publications. Alfred L. Kroeber contributed the first paper, "The Making of the Man," a warm account of Alsberg's personal life. Donald D. Van Slyke reviewed his work in the natural sciences; Fred B. Linton, his career as Chief of the Bureau of Chemistry, U. S. Department of Agriculture; Robert D. Calkins, his life as a university professor and administrator; and John B. Condliffe, the contributions of Alsberg as a social scientist beyond the university. Alsberg's own three papers are well chosen to give an idea of the breadth of the man: "Progress in Chemistry and the Theory of Population," "What the Social Scientist Can Learn from the Natural Scientist," and a Commencement address at Reed College.

HOWARD S. MASON

National Institutes of Health
Bethesda, Maryland

A Concise Encyclopedia of World Timbers. F. H. Titmuss. v + 156 pp. $4.75. Philosophical Library. New York.

OF VALUE primarily to the woodworker rather than to the wood technologist, the macroscopic descriptions of nearly two hundred commercial timbers are concise but hardly encyclopedic. The common names used are those of British commerce. Although a handy and useful book, it is overpriced.

HENRY CLEPPER

Society of American Foresters
Washington, D. C.

CORRESPONDENCE

DEFINITELY NOT

Naturally I don't know how many other SCIENTIFIC MONTHLY readers have written in about this, but even if nobody else did I want you to know that several of my friends and I considered the "modern art" used on pp. 322–328 (May issue) definitely out of place in THE SCIENTIFIC MONTHLY.

I can't criticize Mr. Kahn's drawings à la Aurignacien from the point of view of the art critic, but the readers of THE SCIENTIFIC MONTHLY expect photographs, diagrams, and drawings, and not nonsense, especially such as appears on pages 324 and 327.

If this should become a trend we'll have to open SCIENTIFIC MONTHLY with trepidation; any moment you might spring Tovarisch Picasso on us. Or are glamour girls in four colors the next item on the list?

WILLY LEY

Montvale, New Jersey

BUT, ON THE OTHER HAND . . .

My dentist tells me that many of his patients speak appreciatively of THE SCIENTIFIC MONTHLY, which we find in his waiting room along with recent copies of popular magazines.

I, a layman, have just reread Stanley A. Cain's article on "Plants and Vegetation as Exhaustible Resources" and chuckled again at Matt Kahn's drawings.

I miss specific reference to healthy human relations in this matter of seeing the problem whole, though I think it is implicit in some of Mr. Cain's statements. Research into the facets of human relations . . . is needed now on a large scale.

LUCILE MALKIN

Vancouver, B. C.
Canada

OUR POLICY IS APPROVED

I am writing to say that I enjoyed reading the article in the April SCIENTIFIC MONTHLY on "La Montaña Llorona" by Archie Carr, Jr.

It is a rare thing for a scientist to write with such literary value; reading it was a genuine treat.

I am glad that your editorial policy approves the inclusion of a wide variety of subjects. As a reader, I also approve. More and more I come to depend on THE SCIENTIFIC MONTHLY to give me a breadth which it would not be easy otherwise to obtain.

DOUGLAS E. SCATES

Office of Naval Research Projects
American Council on Education
Washington, D. C.

PERMISSION GRANTED

This is to inquire from you whether I may translate into Urdu articles out of your magazine, for purposes of broadcasting at the radio. . . . You well know that Pakistan needs to be industrialised. Prior to that, her public has to be made scientific-minded. In allowing me the requested facility, you will be helping the cause of my country, for which I will be very much thankful to you.

F. U. KHAN

Karachi, West Pakistan

OPUS 1 FOR THE NEW HYMNAL

WITH A BOW TO ISAAC WATTS

"The Church of England has appealed for new hymns for the atomic age."—*The New Yorker.*

O God, our help in ages past,
Hear now our brand-new psalm;
We'll sing about a mighty blast,
I. e., the atom bomb.

Under the shadow of Thy throne,
By brains and intuition,
We've builded something all our own
From dust and nuclear fission.

A thousand ages in Thy sight
Have yielded us plutonium;
But watch us change it overnight
To superpandemonium.

Before the hills in order stood . . .
We'll blow the hills to powder.
When Russia has bombs just as good
We'll have 'em even louder.

Time like an ever-rolling stream
Moves to the very brink;
Our will is now the thing supreme.
(It's later than You think.)

Thy word commands our flesh to dust;
Now we revert the process,
And at the world, if cause be just,
We'll thumb our proud proboscis.

O God, our help in ages past,
This is the way we feel:
You've helped us long enough; at last
Move over—we'll take the wheel!

PAUL H. OEHSER

Washington, D. C.